TOTAL 2003 SKY EVENTS COVERAGE • PULL-OUT MAPS

Astronomy's Explore the Universe

9TH EDITION 2003

DISPLAY UNTIL
DECEMBER 31, 2002

Best Images from Hubble's New Camera

HOTTEST COSMIC STORIES OF THE YEAR

50 Great Telescopes Described

How to Find Cool Astro Gear

Extrasolar Planets: Closing in on Earth

astronomy.com
$5.95 • $7.95 Canada
35>
0 74470 08070 1

So, you named your daughter NGC4565. Who says you're obsessed?

Certainly not us.

We understand what drives the journey from casual stargazer to serious astronomer. It's the passion that can keep you awake for three straight days and nights — and we share it.

Seventeen years ago, we released TheSky,™ a program with all of 1,000 stars. It quickly became the gold standard in astronomical software.

We were hooked.

Today, our software allows you to reference more than a half billion celestial bodies, script an evening's viewing, correct for telescope pointing and tracking errors, control digital captures and process images. It even allows you, via the Internet, to operate observatories on the other side of the globe.

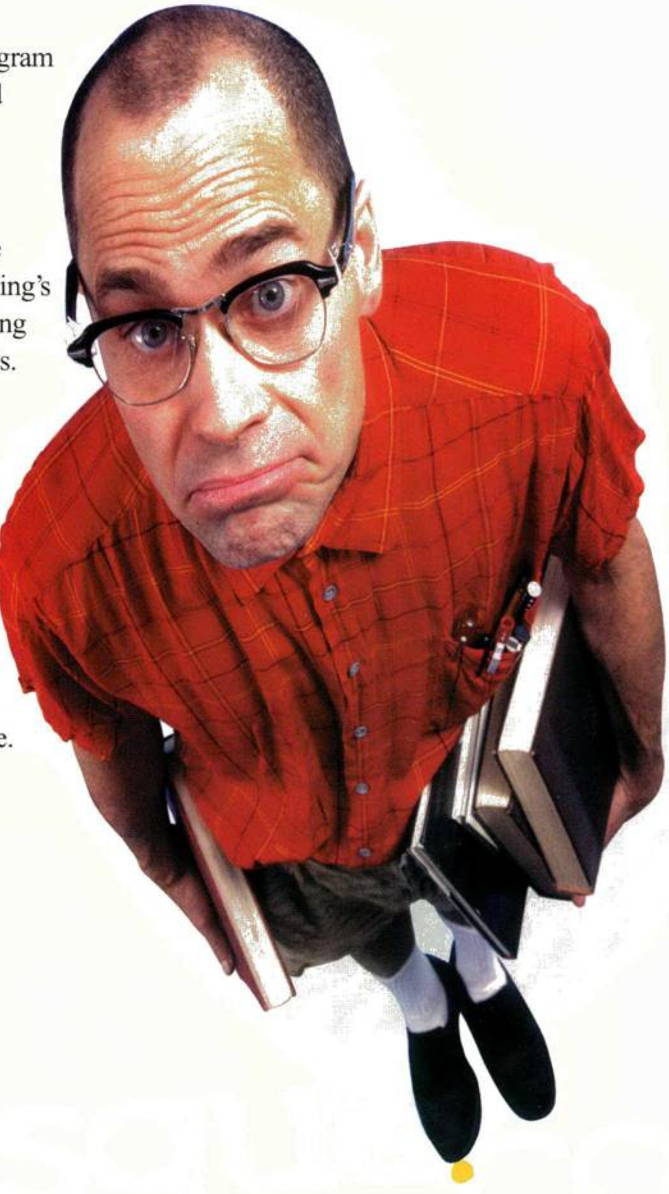
We couldn't stop.

In our spare time, we've created the Paramount GT-1100,™ a robotic telescope mount system so advanced it's blurred the line between professional and amateur astronomy. We've even put TheSky on a hand-held so you'll be able to identify the heavens anytime, anywhere.

Obsession? Who says *you're* obsessed?

THESKY

Astronomy Software
1.800.843.7599

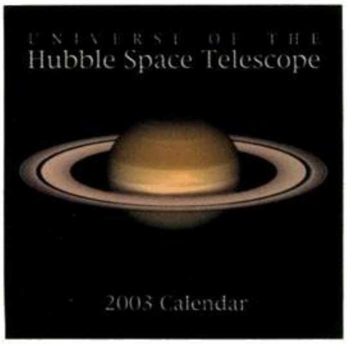


bisque.com

Take your best shot!

WWW.BISQUE.COM SOFTWARE BISQUE, 912 TWELFTH STREET, GOLDEN, COLORADO 80401 U.S.A. THESKY AND PARAMOUNT GT-1100 ARE TRADEMARKS OF SOFTWARE BISQUE

Introducing Astrographics' Skywatching Guide


Universe of the
Hubble Space Telescope
2003 Calendar

Earth from Space
2003 Calendar

International Space Station
2003 Calendar

Dennis Kunkel's
Microscopic World
2003 Calendar

New! *Universe of the Hubble Space Telescope* 2003 Calendar

Our all-new *Universe of the Hubble Space Telescope* 2003 calendar now includes our *Astrographics' Skywatching Guide*. This indispensible guide to the night sky provides night-by-night descriptions of sky events, including planet positions and alignments, lunar phases, solar and lunar eclipses, and much, much more. And the calendar features twelve stunning new Hubble Space Telescope images—of galaxies, gaseous nebulae, planets, and more.

Also available (shown at left): *Earth from Space*, *International Space Station*, and *Dennis Kunkel's Microscopic World* 2003 calendars. (Space calendars contain *Astrographics' Skywatching Guide*; microscopic calendar does not.)

12 by 12 inches • 26 pages • $12.95 each

New! Hubble Space Telescope Posters

Hot off the press, the latest images by the Advanced Camera for Surveys, including the Tadpole Galaxy, Cone Nebula, and Omega Nebula.

24 by 36 inches • $11.95 each or full set for $30.00

Also available (not shown):Hubble Space Telescope posters of the Lagoon Nebula, Hubble Deep Field South, and Antenna Galaxies.

24 by 36 inches • $11.95 each or full set for $30.00

Also available (not shown): Anglo-Australian Observatory posters of the Pleiades, Reflection Nebula in Orion, and Galaxy M 83.

36 by 24 inches • $11.95 each or full set for $30.00

TADPOLE GALAXY
HUBBLE SPACE TELESCOPE

CONE NEBULA
HUBBLE SPACE TELESCOPE

OMEGA NEBULA
HUBBLE SPACE TELESCOPE

Hubble Space Telescope Gallery Prints

Choose from dozens of large-format photographic reproductions of your favorite Hubble Space Telescope images, including the Eagle Nebula, Hubble Deep Field, and many more. Available unmounted or mounted onto a high-density fiber board laminated with crystal-clear epoxy. See our complete selection online.

Unmounted: 20 by 20 inches • $29.95
Mounted: 26 by 26 inches • $119.95

ORDER ONLINE: www.astrographics.com. ORDER BY PHONE: 1–888–8–ASTRO–8 (toll free). ORDER BY MAIL: Astrographics, 85 Oakside Dr., Smithtown, NY 11787. Shipping and handling: calendars, posters, or logs $3.95 per item category per order; gallery prints $5.95 per order unmounted, $34.95 per item mounted.

astrographics.com

Astronomical Observing Log

Astronomical Observing Log
Observing Log

Featuring deep-space images by the Hubble Space Telescope, this elegant observing log provides a convenient way to maintain a permanent record of astronomical observations. Includes log pages, notes pages, introductory text, and 28 full-color photographs. A perfect gift!

7.25 by 8 inches • 112 pages • $17.95

Astronomy's
Explore the Universe
9TH EDITION 2003

Cover Photos, clockwise from top left: Robert Gendler; N. Smith, U. of Minn./NOAO/NSF; NASA/Chandra/D. Wang; Robert Gendler

80 **Best in Class**

Astronomy

COVER

7 ***Astronomy*'s Top Ten**
The most significant cosmic stories of the year span the range from a Leonid meteor storm to new saturnian moons. *Stephen Maran*

20 **Narrowing the Field**
Astronomers are drawing closer to detecting other Earths orbiting nearby stars. *John Armstrong*

28 **New Views of the Cosmos**
New instrumentation on the Hubble Space Telescope has enabled tremendous, stunning views of galaxies and nebulae, made in unprecedented detail. *Elesa Janke*

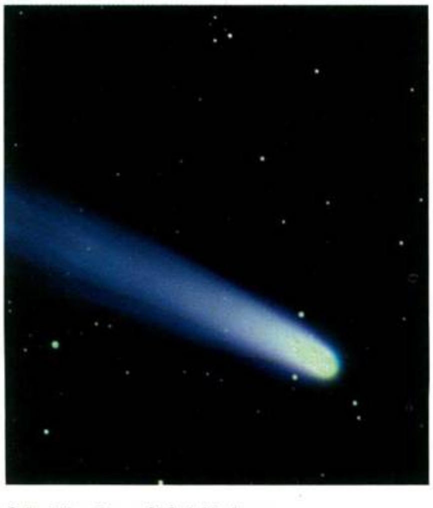
39 ***Astronomy*'s 2003 Guide to the Sky**
Keep current with sky events all year long using our in-depth calendar and you won't miss a meteor shower, eclipse, or opposition. *Martin Ratcliffe and Rich Talcott*

66 **Cool Gear for Cold Nights**
A guide to the best cold-weather accessories to make this winter's stargazing the most comfortable and most productive it can be. *Maggie McKee*

72 **Into the Ever-Stranger Cosmos**
The deeper astronomers look, the weirder the universe becomes. *Christopher Conselice*

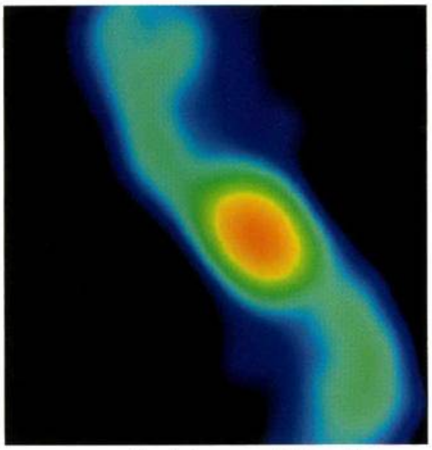
80 **Best in Class**
Fifty choice telescopes chosen to highlight observing and imaging goals offer a wide array for prospective telescope buyers. *Phil Harrington*

94 **The Beautiful Universe**
Our readers capture some of the most stunning sights visible in the night sky.



94 **The Beautiful Universe**

Mathew Russell



7 ***Astronomy's*** **Top Ten** NRAO

72 Into the Ever-Stranger Cosmos

NASA and the Hubble Heritage Team

HOTHANDS-2®
HAND WARMER
LASTS UP TO 10 HOURS • SAFE • NATURAL HEAT
NO ODOR • NON-TOXIC
Proudly made in
USA
BY HEA
TEAR
HOTHANDS-2 BY HEATMAX TM

66 Cool Gear for Cold Nights

Astronomy: Bill Zuback

20 Narrowing the Field

Lynette Cook

At *the* Eyepiece

Explosive Science

Every day it becomes clearer and clearer. A walk through last year's American Astronomical Society (AAS) meeting in Washington revealed the dream of astrophysicists twenty years ago — so much important news and significant research projects that they could not be contained within a week of nonstop talks. An explosion of amazing discoveries and results now bombards us every month, many with spectacular images attached.

Steve Maran, press officer of the AAS, has summarized the top 10 astronomical stories of last year in this issue of *Explore the Universe* (see p. 7). His collection includes concise, precise reviews of the 2001 Leonid meteor storm; the landing of the NEAR spacecraft on asteroid 433 Eros; the detection of an object lodged in the "cosmic dark age," shortly after the Big Bang; and a slew of others that will update you on the biggest stories of recent vintage, and point the way toward tomorrow's biggest news.

Another remarkable, recent discovery is Caltech astronomer David Charbonneau's detection of the first known atmosphere around an extrasolar planet, a Jupiter-like body orbiting the star HD 209458, which is a sunlike orb some 900 trillion miles away toward the constellation Pegasus. John Armstrong's story on this planet and others (p. 20) reveals how close NASA and other agencies are to launching telescopes that will find not only big, gas giant planets around other stars, but also little, rocky ones like Earth.

With such voluminous discoveries taking place, how is an amateur astronomer to keep up with the myriad new kinds of objects in the cosmos? Caltech astronomer Christopher Conselice provides a rollicking tour of the major types of objects now known (p. 72), from galaxy superclusters to denizens of the Milky Way to our own sun's planets, asteroids, and Kuiper Belt of debris. Moreover, editors Elesa Janke and Rich Talcott provide a stunning look at images from Hubble's new Advanced Camera and NICMOS, resulting in a memorable gallery (p. 28).

A glance behind the newest scientific curtains represents only a piece of *Explore the Universe*. Contributor Martin Ratcliffe and editor Rich Talcott expertly draw you through 25 pages of the greatest annual Sky Guide in print (p. 39), with sufficient maps, diagrams, and photos to provide a heads-up for all of 2003's major sky events. Telescope expert Phil Harrington brings you one of his annual guides to choosing and using telescopes, this time focusing on 50 models that represent the best values for specific types of observing and imaging — casual, lunar and planetary, deep-sky, CCD, and so on (p. 80). To keep you warm and comfortable while observing with those scopes, editor Maggie McKee has composed a guide to astro gear and accessories that you will not want to be without on wintry nights under the Milky Way (p. 66).

As always, let us hear from you. We would love to know what you are doing under the stars, whether it be serious viewing, photography, CCD imaging, or simply casually exploring the universe.

Dave Eicher, Editor

Explore the Universe
8TH EDITION 2002

EDITORIAL STAFF

Editor	David J. Eicher
Senior Editor	Richard Talcott
Associate Editor	Maggie McKee
Associate Editor	Paul Morledge
Copy and Photo Editor	Elesa Janke
Editorial Associate	Terry Williams Conley
Editorial Assistant	Julie Sherwin
Editorial Director	Bonnie Bilyeu Gordon

ART STAFF

Art Director	Carole Ross
Senior Graphic Designer	Patti L. Keipe
Graphic Designer	Tonya Benson
Illustrators	Terri Field, Kellie Jaeger, Elisabeth Rowan

PUBLISHER

Publisher	James J. Slocum

KALMBACH PUBLISHING CO.

President	Gerald B. Boettcher
Vice President, Advertising	Scott Stollberg
Vice President, Marketing	Michael Stephens
Corporate Art Director	Maureen Schimmel
Production Manager	Annette Wall
Advertising Services Manager	Sara Malin Everts
Circulation Director	Jerry Burstein
Circulation Specialist	Kirsten King
Circulation Coordinator	Kelly Ivan

ADVERTISING DEPARTMENT (800) 558-1544

Advertising Sales Manager	Dan Koehler dkoehler@astronomy.com
Advertising Sales Representative	Ken Kozerski kkozerski@astronomy.com
Ad Services Representative	Marie De Grave mdegrave@kalmbach.com

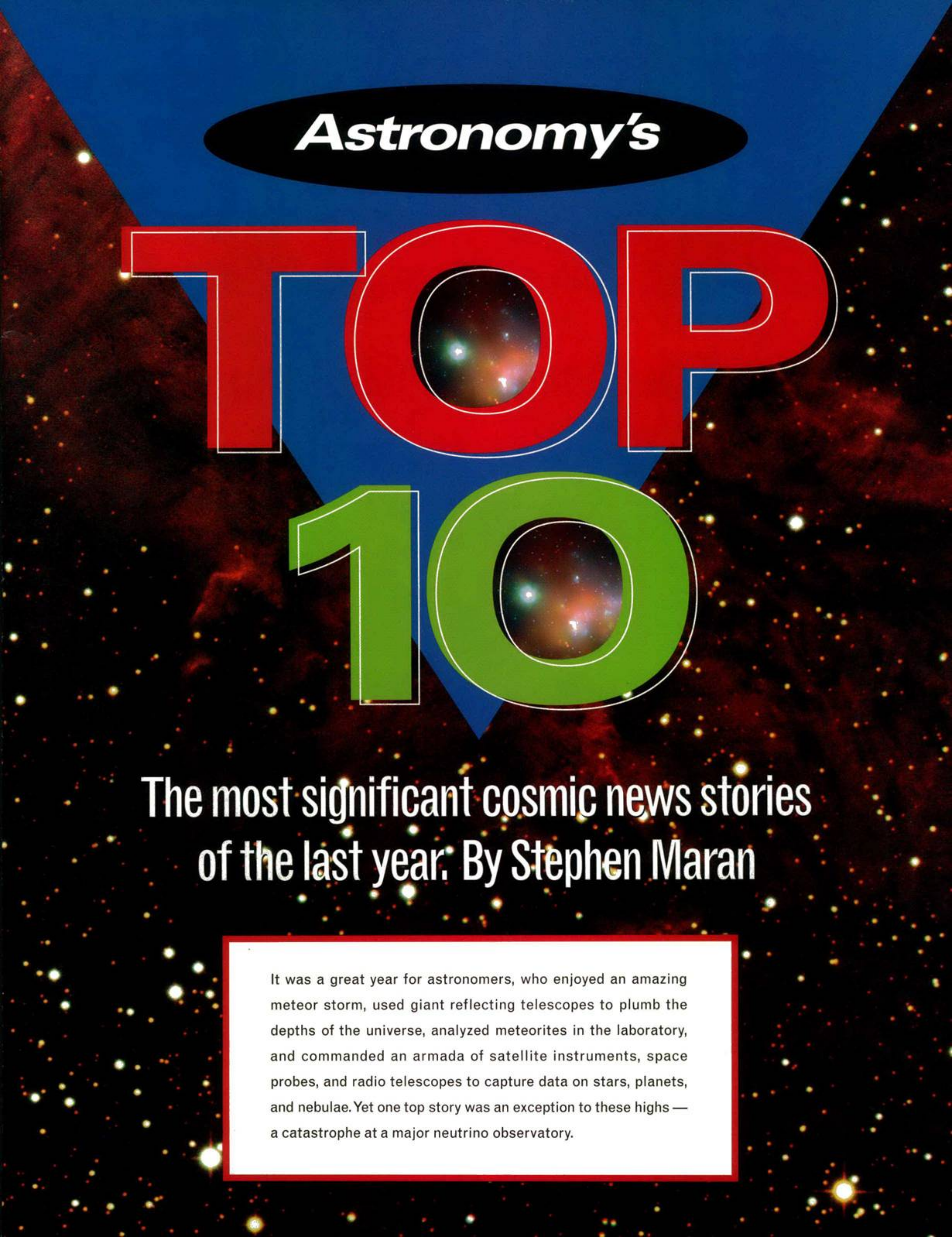
U.S., Canadian, and International Newsstand Distribution:
Comag Marketing Group, New York, NY 10019

Astronomy Home Page: http://www.astronomy.com

Explore the Universe 2003 (ISSN 1089–4926) is published annually by Kalmbach Publishing Co., 21027 Crossroads Circle, P.O. Box 1612, Waukesha, WI 53187–1612. *Astronomy* editorial phone: (262) 796-8776; advertising: (800) 558-1544; customer service: (800) 446-5489; subscriptions: (800) 533-6644, 7 days a week, 24 hours a day; fax: (262) 796-0126. SINGLE COPY PRICE: U.S. $5.95, Canada $7.95, and U.K. £2.75. Canadian price includes GST. BN 12271 3209 RT. Canadian and international orders payable in U.S. funds. POSTMASTER: Send address changes to: *Exploring the Universe 2003*, Kalmbach Publishing Co., 21027 Crossroads Circle, Waukesha, WI 53187–1612.

Copyright © 2002 Kalmbach Publishing Co. Title registered as trademark; all rights reserved. Material in this publication may not be reproduced in any form without permission.

Standard class postage paid at Waukesha, WI, and additional offices. Printed in the U.S.A.



Astronomy's TOP 10

The most significant cosmic news stories of the last year. By Stephen Maran

It was a great year for astronomers, who enjoyed an amazing meteor storm, used giant reflecting telescopes to plumb the depths of the universe, analyzed meteorites in the laboratory, and commanded an armada of satellite instruments, space probes, and radio telescopes to capture data on stars, planets, and nebulae. Yet one top story was an exception to these highs — a catastrophe at a major neutrino observatory.

1

The Leonid Meteor Storm

The top story was the spectacular return of the Leonid meteors over North America and Australia on November 18, 2001, and Japan on November 19. Count rates estimated at different locations ranged above 1,000 meteors per hour in the United States and to more than 300 meteors per minute for brief moments in Japan. It was the greatest show since the 1966 Leonids, and for many young astronomers, by far the best of a lifetime.

As hundreds of thousands, perhaps millions, of people watched from the ground, investigators tracked the Leonids from an instrument-packed aircraft and photographed the falling, flashing space dust from the ground. At Poker Flat, Alaska, an electronic camera took a succession of still images at 1,000 frames per second, capturing for the first time views of the shock wave produced when the small solid particle underlying the meteor — the meteoroid — plunged into Earth's atmosphere at 44 miles (71 km) per second. Meteor experts were surprised at the size of a visible bow shock, estimated at about 500 feet (152 m), or longer than a football field.

Early observations of the Leonids became central to our understanding of meteor showers in general. As early as the 10th century the Leonids were characterized by such expressions as "stars falling like rain." Similar descriptions of a sky zig-zagged with fiery streaks continued for the next several centuries. Curiously enough, records of Asian, Muslim, and European peoples revealed that the Leonids occurred in roughly 33-year intervals.

NASA/ Juraj Toth

Reports from the night of November 12/13, 1833, described people by the thousands startled awake by the screams of others who saw fireballs rage over much of the sky. Some who witnessed this event believed the apocalypse had finally come.

By the end of the 18th century, scientists Heinrich Brandes and Johann Benzenberg (both from the University of Göttingen) had carried out observational studies of several meteor showers. They discovered that meteors became visible at an average height of 60 miles (97 km). But perhaps their biggest find was that meteors of a given shower appeared to radiate from one spot in the sky. This observation led other astronomers to conclude that meteors move around the sun in elliptical orbits and that meteors themselves are little more than debris trailing off of comets.

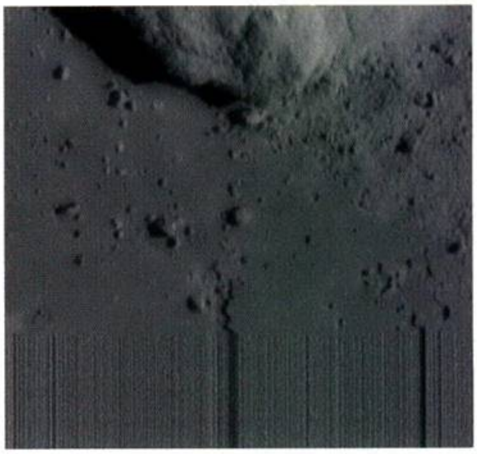
2

NEAR Landing on Eros

Story No. 2 was a milestone in interplanetary exploration — the first landing on an asteroid. The Near-Earth Asteroid Rendezvous (NEAR) mission, which was not designed to land, nevertheless reached the surface of Eros, the second-largest near-Earth asteroid, on February 12, 2001. The probe's Gamma-Ray Spectrometer (GRS) remained in working order after touchdown and continued to transmit measurements until ground controllers terminated the mission one week later.

Prior to landing, NEAR had flown by the smaller asteroid 253 Mathilde, then spent a year orbiting 433 Eros as the asteroid itself circled the sun. The probe's controlled descent allowed an on-board camera to snap pictures of the asteroid until NEAR was within 394 feet (120 m) of the surface. The sharpest photographs showed features as small as one-half inch (1 cm) across. These descent images confirmed two striking features of the potato-shaped 21 by 8 by 8-mile (34 by 13 by 13-kilometer) body that were suggested by earlier NEAR photography: omnipresent blocks and conspicuous "ponding."

Everywhere on Eros, there are "blocks" or boulders of what likely is compacted regolith or surface material, some as wide as a football field is long (100 m). Geologists found 6,760 blocks larger than 50 feet (15 m) across on Eros, and concluded that most were ejected from the 4.7-mile (7.6 km) Shoemaker crater, which appears to be the youngest significant crater on the asteroid.



NEAR captured this last image of 433 Eros from an altitude of 394 feet before the probe landed on the asteroid. However, the sturdy little spacecraft continued to send and receive radio signals until NASA finally severed ties. JHU/APL

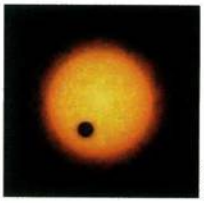
Within craters and other depressions there are smooth areas that must consist of fine rock powder or pebbles too small to be distinguished even in the sharpest images. These "ponded deposits" appear sedimentary in nature, like silt in a river delta on Earth, although the physical process that would sift and transport such small particles on the airless, waterless asteroid are unknown. Ponding has not been found on any other asteroid.

Space scientists can now look forward with great confidence to missions aimed at meeting up with and settling down on another interplanetary body: a comet.

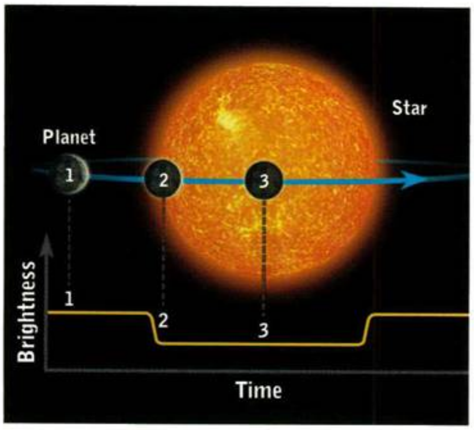
3

"Direct Detection" of an Exoplanet

Number 3 on your *Astronomy* Hit Parade is a continuing saga that's been making news since 1992: the hunt for planets of stars beyond the sun. At press time more than 100 "extrasolar planets," or "exoplanets," have been found. The main event in 2001 was the first direct detection of such a planet, HD 209458B, through observations with a spectrograph on the Hubble Space Telescope. HD 209458B is the first extrasolar planet known to transit the disk of its parent star from our earthly vantage point. "Direct detection" means observing some property of the planet itself. In contrast, all prior detections were "indirect" — revealed by the wobble of the planet's parent star, or in the case of the first known extrasolar system, its pulsar. (HD 209458B was also detected by a second indirect method, through a tiny reduction in the light of its star as seen from Earth when the planet passes across the stellar disk every 3.5 days.) Hubble's landmark direct detection was made by precision observations of star HD 209458 during each of three planetary transits. These revealed that the partially occulted star was about 0.02 percent dimmer in the light of the sodium "D" absorption lines (the spectral features that make sodium lamps yellow) than at adjacent wavelengths. This was consistent with the prediction of sodium atoms in the planetary atmosphere, which absorbed starlight passing through the atmosphere at the limbs of the planet. David Charbonneau of Caltech led the research team.


NASA

Starlight will dim slightly when a planet (or satellite) crosses, or transits, our earthly line of sight to that particular star. *Astronomy*: Elisabeth Rowan



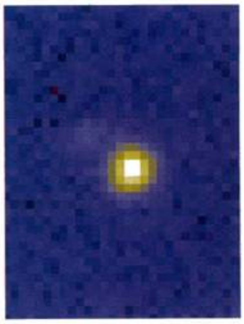
With increasing capabilities to detect and analyze extrasolar planetary atmospheres, astronomers will have an edge on targeting potential earthlike and, quite possibly, habitable planets.

Taking the direct detection scheme to an entirely new level of sophistication, telescope designers extraordinaire Roger Angel and Neville Woolf at the University of Arizona are developing and refining a revolutionary telescopic technique called "nulling interferometry." Similar in function to a coronagraph, Angel's design will essentially block the light of a parent star to such a degree that astronomers may some day capture images of not only planetary atmospheres, but quite possibly even the surfaces of alien worlds.

4

A "Dark Ages" Object Emerges

Astronomers pushing the limits of present technology struck pay dirt when they identified the first known cases of quasars shining forth from within and just after the "dark ages." Accordingly, the researchers set the stage for a prime goal of the planned Next Generation Space Telescope — to explore the universe during that era and examine the first stars and galaxies. "Dark ages" is a term introduced by Astronomer Royal Sir Martin Rees to describe an interval of time that began about 300,000 years after the Big Bang. The dark ages lasted for hundreds of millions of years. During this time, space was filled with neutral hydrogen, which absorbed all light at wavelengths equal to or below the characteristic Lyman-α line of hydrogen at 121.6 nm. Eventually ultraviolet light from the ignition of numerous quasars and large numbers of massive young stars in newborn galaxies ionized the hydrogen gas, making it transparent to those same wavelengths.



Is the quasar SDSS 1044-0125 a denizen of the cosmic "dark age"? SDSS

As we look to greater distances, we are seeing back in time, so the most distant known quasars are the likeliest targets for denizens of the dark age. Two such quasars, discovered by the Sloan Digital Sky Survey at the Apache Point Observatory near Cloudcroft, New Mexico, showed evidence of dense hydrogen absorption along the most distant parts of the line of sight. This effect, detected with the APO 3.5-meter reflector and clearly confirmed with the 8-meter Keck II Telescope on Mauna Kea, Hawaii, was reported in August 2001 by Robert H. Becker (University of California, Davis) and co-workers.

And lest it be regarded as a random phenomenon, another team under S. George Djorgovski (Caltech) reported similar findings. Djorgovski, using Keck II and Keck I, found that another, slightly less distant quasar showed substantial darkening below Lyman-α, but not the complete blackout observed by Becker. Becker's quasar is at redshift 6.28, and Djorgovski's is at 5.73. Each of these redshifts is so large that it's difficult to state the corresponding distance without having precise knowledge of the history of the expansion of the universe, but in any case they are seen as they appeared when the universe was less than one-tenth of its present age.

If the Becker and Djorgovski findings are representative of the ancient universe, then the dark ages must have ended around the time corresponding to redshift 6, contrary to existing cosmological theories, which generally put the end at redshift 7.

Additionally, astrophysicists seeking the ultimate architecture of the universe should find data about the final days of the dark ages as fundamental to the cosmic blueprint.

5

The Tagish Lake Meteorite

An extraordinary meteorite arrived at Earth on January 18, 2000, with an explosion high above Tagish Lake in the Yukon Territory of Canada. Pieces of the 200-ton rock rained down on the frozen lake and were collected by a quick-thinking Yukon resident.

Because the samples were collected so soon after the explosion, the pieces of space rock were not exposed to any earthly weathering. The chemical and physical make-up of the meteorites remained relatively unchanged. In fact, laboratory analyses identified the Tagish Lake Meteorite as the most pristine known sample of a primitive meteorite, and other tests of it detected sugars for the first time in such space rocks.

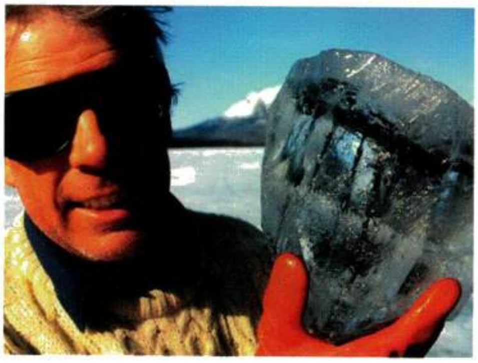
"Pristine" means the meteorite was virtually uncontaminated by the frozen lake surface in Canada where the Tagish Lake stone fell and was collected. "Primitive" indicates that it has been little altered since it formed as part of a "parent body" or early asteroid in the solar nebula, the birth cloud of the solar system.

Researchers under Sandra Pizzarello at Arizona State University reported in September 2001 that the Tagish Lake Meteorite contains numerous organic compounds, but less amino acid content than expected from a standard of comparison — the primitive Murchison Meteorite — which fell in Australia in September 1969.

In addition, researchers found fullerenes, or buckyballs, soccer ball-shaped carbon molecules consisting of 60 or more atoms each, in the Tagish Lake Meteorite. Moreover, the noble gases helium and argon found trapped in these fullerenes exist in isotopic proportions resembling those in planetary atmospheres, which differ markedly from those in the sun. Thus the gases are a sample of the primitive solar nebula, and were not implanted by the meteorite's exposure to the solar wind.

In December 2001, another research team reported the uncovering of some simple sugar compounds in the Murchison Meteorite and another primitive stone — the Murray Meteorite. These findings further fuel the contention that objects falling on early Earth may have helped seed the planet with the organic compounds so essential to the development and maintenance of life as we have come to know it.

The University of Calgary's Alan Hildebrand shows off the most pristine space rock ever uncovered here on Earth. UWO/NASA



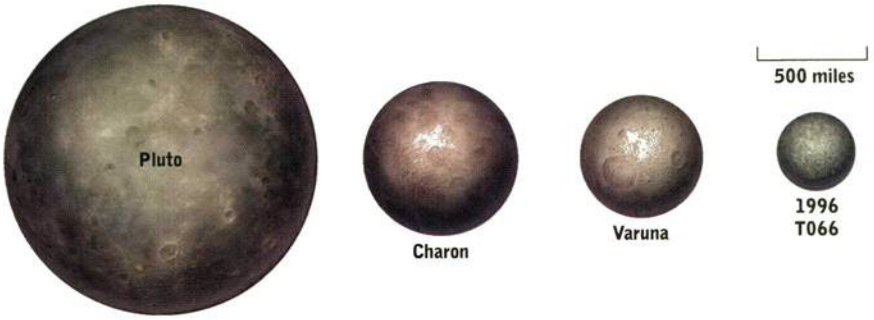
6

Kuiper Belt Surprises

The periphery of the solar system is fertile ground for discoveries as astronomers survey it with ever-improving sensitivity. This work bore fruit when the largest object in the Kuiper Belt other than Pluto and its moon Charon was reported in May 2001. Object (20000) Varuna, discovered on November 28, 2000, by the Spacewatch telescope in Arizona, was later observed with the James Clerk Maxwell Telescope (JCMT) and the University of Hawaii (UH) 2.2-meter telescope, both on Mauna Kea. Combining submillimeter wavelength (i.e., waves longer than infrared and shorter than radio) measurements from the JCMT with visible light measurements from the UH telescope, investigators led by Hawaii's David Jewitt found that Varuna is 560 miles (900 km) in diameter, versus 746 miles (1,200 km) for Pluto's moon Charon and about 1,491 miles (2,400 km) for Pluto itself. Varuna is noticeably darker than either Pluto or Charon, suggesting that unlike them, it has no extensive reflective frost on its surface. The findings give added weight to the suspicion that there are Pluto-sized or larger objects deep in the Kuiper Belt yet to be discovered.

In early 2001, a team of European astronomers claimed to have caught an even bigger fish than Varuna from the depths of the Kuiper Belt. To estimate this new object's (2001 KX76) size the astronomers decided to "look back in time" using the virtual telescope called Astrovirtel, which performs automated searches through thousands of archived images of the sky. Then, using what is known about 2001 KX76's orbital behavior and albedo, the team figured this KBO might boast a diameter of up to 745 miles (1,200 km).

Above: Varuna spotted in a deep-field image. ESO
Below: How Varuna shapes up with other KBOs.
Astronomy: Elisabeth Rowan



7

Tantrums in the Galactic Center

Astronomers using the Chandra X-ray Observatory announced in September 2001 that the orbiting facility had detected a huge outburst or flare of x rays from the center of the Milky Way on October 26–27, 2000. The measurements provided strong new evidence for the existence of a supermassive black hole at the galactic center. And, Chandra images of a large region around the galactic center provided a spectacular mosaic of previously unseen phenomena, including about 1,000 point-like x-ray sources of which less than 20 had been individually detected before.

During the October 2000 flare, which lasted about three hours, the x-ray emission from the galactic center object, Sagittarius A*, increased by a factor of 45, according to researchers led by Frederick K. Baganoff of the Massachusetts Institute of Technology. Such outbursts may be related to the fall of doomed matter into a black hole. Less dramatic but more telling, at one point during the flare, the emission dropped precipitously, declining by a factor of five in just 10 minutes.

Astronomers already knew that there is an unseen 2.6-million-solar-mass object at the galactic center, but its size was not well determined: From previous observations, it could be as large as the solar system, which is much wider than a black hole of that mass. However, the short, steep drop in x-ray emission means that the radiating source is no larger than about 10 light-minutes, slightly more than the radius of Earth's orbit around the sun. The smaller the radius of a supermassive dark object, the more likely it's explained by the presence of a black hole.

Chandra's survey of a large region around the galactic center detected both the 1,000 point sources mentioned above and glowing x-ray nebulosity. However, the extent and luminosity of the diffuse x-ray emission was much less than found by previous observations with less capable x-ray telescopes than Chandra. And, the nebular emission corresponded to an emitting source or sources much cooler than the previously estimated 100 million K. What happened to the brighter glow seen before?

Q. Daniel Wang of the University of Massachusetts, Amherst, proposes that it was likely the result of the emissions of hundreds of the newfound point sources combined with the x-rays coughed up by Sagittarius A* long ago, when it could have been brighter. However, bouncing off interstellar dust and gas clouds in the Milky Way, the diffuse emission took much longer paths and is only now reaching the vicinity of Earth.

Fire in the belly of the Milky Way.

Imaged by the Chandra X-ray Observer

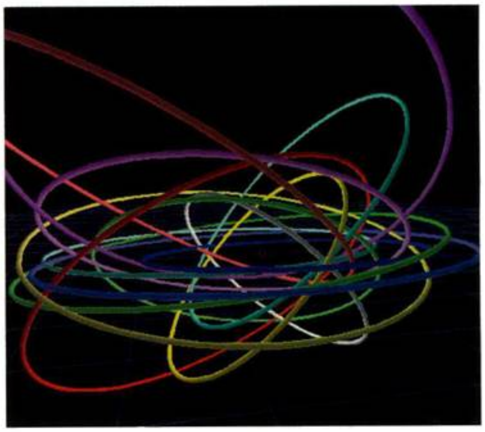
8

New Moons of Saturn

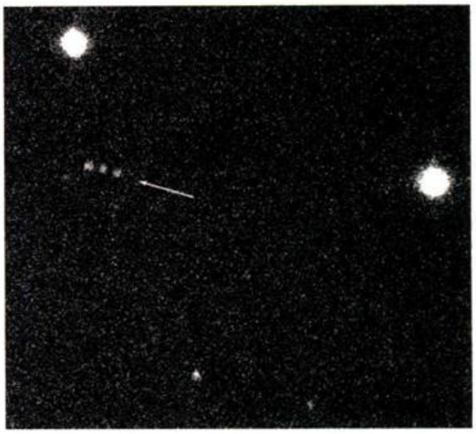
Any time astronomers discover a dozen new moons the story has got to make *Astronomy's* Top Ten. So a report by a team under Brett Gladman (Observatoire de la Cote d'Azur) is next on the list. Using wide-field cameras on the 2.2-meter reflector at the European Southern Observatory, the 3.6-meter Canada-France-Hawaii Telescope, and a 1.2-meter telescope on Mount Hopkins, in Arizona, the team detected a dozen new moons and then determined their orbits with additional telescopes in California, Arizona, and Chile. The survey is thought to have found all of Saturn's satellites with diameters of 3.7 miles (6 km) or more.

The new moon's orbits revealed a previously unknown circumstance among planetary satellites: the orbital parameters are not all different, but are clustered around a few seemingly chosen values. Such a find revealed that the leading theory for so-called irregular planetary satellites (small moons in big orbits with high eccentricity and/or high inclination to the planetary equators — a definition that fits the new Saturn dozen) is wrong.

According to that theory, irregular satellites began as asteroids, then were captured by planets. But in that case, there's no reason that their orbits should cluster around certain values. The new paradigm: Irregular satellites are fragments of larger moons that were disrupted by impacts of interplanetary objects, most likely comets. These new satellites then follow orbits similar to their parent moons.



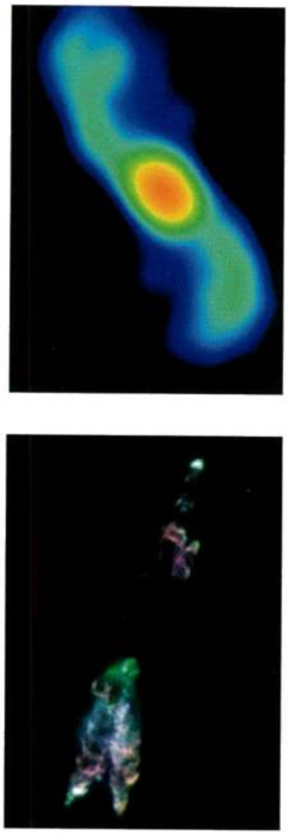
Scientists from Project Pluto created this computer-generated diagram of the orbital trajectories behind Saturn's 12 newfound satellites. Project Pluto



The arrow points to a combination of three successive exposures of the second saturnian moon S/2000 S 2. ESO

9

Caught in the Act



Top: Radio image of K3-35 in Vulpecula the Small Fox NRAO
Bottom: An HST image of proto-planetary nebula CRL 618 NASA

Radio astronomers using the Very Large Array at the National Radio Astronomy Observatory in Socorro, New Mexico, captured what may be the earliest known images of the transformation of a red giant star into a planetary nebula. The observers, led by Luis F. Miranda of the Instituto de Astrofisica de Andalucia in Granada, Spain, concluded that the object studied, K3–35 in Vulpecula, could not have entered the planetary nebula stage before 1984. Otherwise, the water molecules that produced the observed emission would have been destroyed by the same ionizing stellar radiation that makes the nebular gases glow.

These transition objects are often referred to as proto-planetary nebulae. They are usually born from red giant carbon stars and evolve rapidly. They exist for only a few hundred to perhaps one thousand years — an astronomical blink of an eye. Because of their rapid evolution, they are extremely rare and difficult to find and photograph. Beginning in the early 1980s, some astronomers began to hunt down these elusive and fleeting creatures. Since then, there have been approximately 30 objects identified as proto-planetary nebulae.

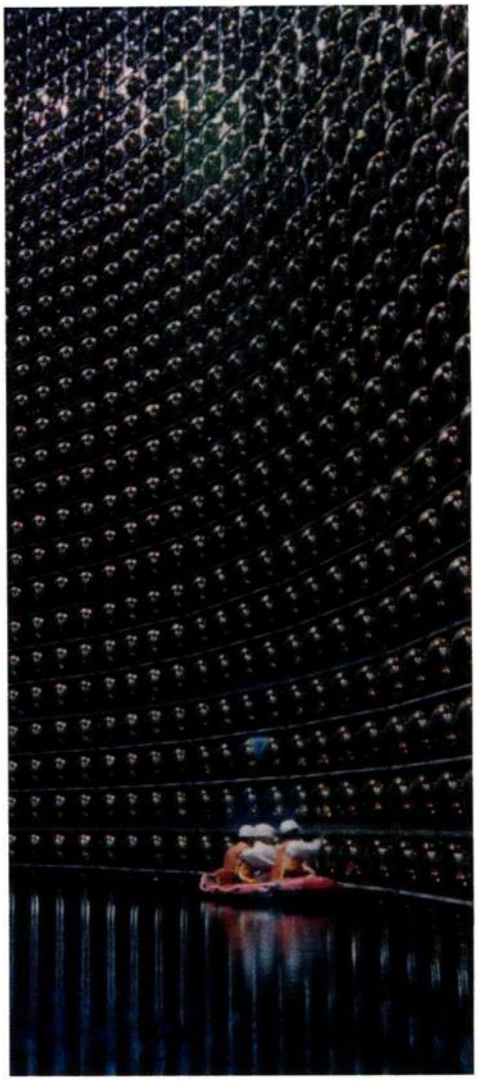
After many hours of observing these short-lived objects, astronomers have discovered that they show off a much richer chemical spectrum than ever expected, such as the signatures of so-called aliphatic carbon chains (aliphatic chains are commonly found in fats and hydrocarbons), which themselves are often attached to even more complex carbon molecules known as aromatic rings. Some scientists now theorize that when these carbonaceous substances formed, they were made in a disorganized manner with a mixture of chemical structures. But then allow a little time for exposure to intense ultraviolet radiation from the parent star, and these molecules shed part of their disjointed outer structures and transform into more interesting and biologically significant aromatic compounds.

10

The Super-Kamiokande Disaster

Disaster strikes: On November 12, 2001, a freak accident wreaked havoc in the then-partially-filled underground water tank that holds 11,000 huge photomultiplier tubes in the Super-Kamiokande neutrino detector at Kamioka, Japan. Aghast staff members found that 6,779 sensors had been destroyed. The accident occurred shortly after technicians replaced some defective tubes in the tank, which required walking on tubes, albeit with styrofoam pads to soften the load.

Subsequent investigations suggested that the neck of at least one tube suffered a small crack, causing it to break under the weight of overlying water when the 41-meter-high tank (which had been drained for the servicing work) was refilled. As the tube popped, it apparently set off a shock wave that raced through the water, causing tube after tube to implode. This accident shut down a premier facility for observation of solar neutrinos and neutrinos from cosmic-ray interactions with Earth's atmosphere, which was also part of a worldwide watch for neutrinos from a supernova, and a laboratory for experiments in basic physics. Scientists now hope to build a new series of neutrino detectors in such a manner that they won't be prone to cracks or breakage .



Workers stay afloat on a raft as they maintain some of the thousands of photomultipliers immersed in 50,000 tons of water. Research Center for Cosmic Neutrinos, ICRR, The University of Tokyo

Stephen P. Maran, a member of *Astronomy's* Editorial Advisory Board, is a 33-year veteran of the space program and the recipient of the NASA Medal for Exceptional Achievement. Minor Planet 9768 is named "Stephenmaran" in recognition of his work. His books include *Astronomy for Dummies®* and *The Astronomy and Astrophysics Encyclopedia*.

LOWEST GUARANTEED PRICES

MEADE

ETX90 OTA $149
ETX DRIVE BASE $79
8" S/C #56 f6.3
COMPUTERIZED
W/WEDGE, TRIPOD $1495
FILTERS from $9
EYEPIECES from $19
TRIPODS from $28
CAMERA ADAPTERS $10
CARRY CASES from $49

CELESTRON
EQ Mounts with Tripods
G5 MOUNT $279
DUAL AXIS MOTORS $148
FILTERS
(.96) 1-1/4 - 2"
Most Colors from $9 ea.
DELUXE LED LITE $12
TELRAD $35
+DEW SHIELD CTG
DEALER - VENDOR
INQUIRIES INVITED
Telescopes
Binoculars
Astro Accessories
BAUSCH & LOMB
BUSHNELL

WWW. ASTROPTX.COM

• PUBLIC WELCOMED • NO SALES TAX COLLECTED
• SHOWROOMS: 57 NORTH STREET/ SUITE 401, DANBURY, CT 06810
• PHONE ORDERS 9AM-9PM (7) DAYS A WEEK
E-Mail: astroptx@astroptx.com JCB

WHOLESALE OPTICS

59 MINE HILL ROAD, NEW MILFORD, CT 06776
WHOLESALE OPTICS CATALOG (over 3lbs.) $10
CALL (860) 355-3132*

focus camera, inc.
800-221-0828
NY S:718-437-8810/Fax:718-437-8811 • orders@focuscamera.com

NEW YORK'S PREMIER PHOTOGRAPHY SOURCE FOR OVER 37 YEARS

Specialists in Telescopes, Binoculars, Spotting Scopes Digital Cameras & Accessories

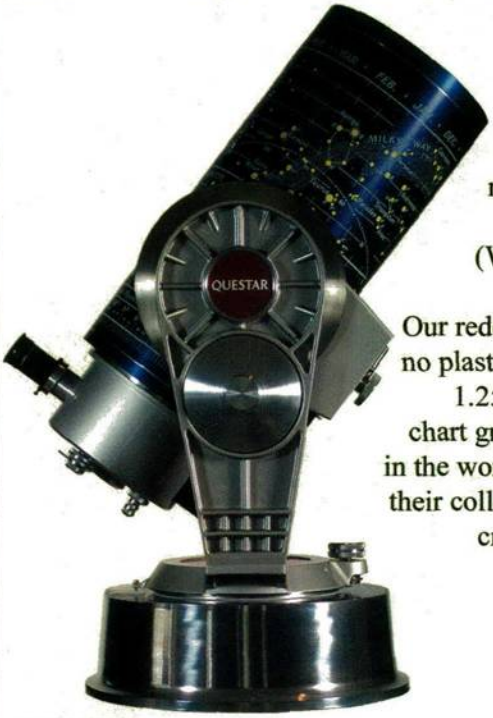
Fully Secure Ordering Online!
www.focuscamera.com
Over 15,000 Product Descriptions Online

- Explore our online telescope and binocular buying guide and ordering service, or call Toll-Free to order by phone
- Huge assortment of astronomy products **In Stock**, for **immediate delivery**
- **Meade Authorized Advanced Products** mail order dealer
- Serving customers honestly since 1964
- Celestron, TeleVue, Kowa, Bushnell/B&L, Fujinon, Leica, Swift, Zeiss, Canon, Nikon, Olympus, Fuji Digital & many others.

Introducing our ***NEW*** Lightweight Titanium 7"

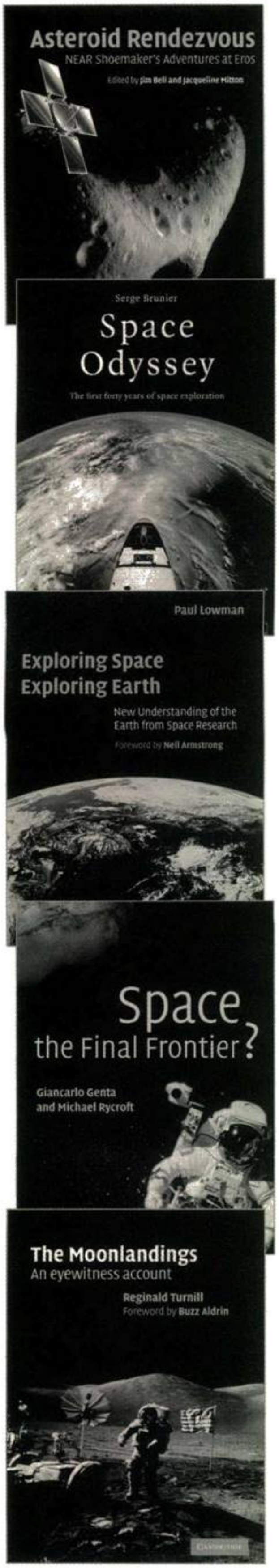
We've taken our world-renowned Classic 7 inch and redesigned all of our internals to incorporate many new technologies that we've borrowed from our existing aerospace and surveillance satellite experience. All of our internal stainless steel components are now titanium. Extensive heat transfer analysis has been used to refine internal components to rapidly chill our optics and dissipate heat. (We have not added an internal fan because we still take a tremendous amount of care and time to insure our internals are dust free.) Our redesign removes 4 pounds from our instrument and still uses absolutely no plastic. Our control box can now use 2" eyepieces as well as our excellent 1.25" Brandons. And to make it even more beautiful - our trademark star chart graces the 7" barrel and our moon map rides on the dew cap. Everyone in the world knows us for our 3 1/2" scope and we hope they will add the 7" to their collection. Having the best optics in the world, we take great pride in our craftsmanship and design and we are still the only 100% made in USA telescope. That's a nice feeling.

The 7" lightweight titanium, 2540mm f/14 - available in Pyrex, Mag Fluoride, Broad Band, Zerodur and Quartz from $8599.



QUESTAR.
The Optical Innovators

New Hope, PA 800 247 9607 www.QuestarCorporation.com


Asteroid Rendezvous
NEAR Shoemaker's Adventures at Eros
Edited by Jim Bell and Jacqueline Mitton
Serge Brunier
Space Odyssey
The first forty years of space exploration
Paul Lowman
Exploring Space Exploring Earth
New Understanding of the Earth from Space Research
Foreword by Neil Armstrong
Space the Final Frontier?
Giancarlo Genta and Michael Rycroft
The Moonlandings
An eyewitness account
Reginald Turnill
Foreword by Buzz Aldrin

Expand your Horizons

Asteroid Rendezvous

NEAR Shoemaker's Adventures at Eros

Jim Bell and Jacqueline Mitton, Editors

with a foreword by Carolyn Shoemaker

The dramatic story of the mission to the near-Earth asteroid Eros, from initial concept studies to the first-ever landing of spacecraft on an asteroid, and subsequent discoveries.

0-521-81360-3 Hb $30.00

Space Odyssey

The First Forty Years of Space Exploration

Serge Brunier

Drawing from the experiences of the 400 men and women who have traveled in space, recounts the greatest moments of the first forty years of space exploration.

0-521-81356-5 Hb $40.00

Exploring Space, Exploring Earth

New Understanding of the Earth from Space Research

Paul Lowman

with a foreword by Neil Armstrong

Illustrates how the exploration of space has led to a far deeper understanding of our planet and describes the impact of space flight on geology and geophysics.

0-521-89062-4 Pb $45.00

Space, the Final Frontier?

Giancarlo Genta and Michael Rycroft

Illustrates the imaginative possibilities that the exploration and subsequent exploitation of space opens up for humankind.

0-521-81403-0 Hb $29.00

The Moonlandings

An Eyewitness Account

Reginald Turnill

with a foreword by Buzz Aldrin

An eyewitness account of the Soviet-American race to land a man on the moon.

0-521-81595-9 Hb $27.00

How to Use a Computerized Telescope

Practical Amateur Astronomy, Volume 1

Michael A. Covington

Explains the step-by-step process to get your computerized telescope up-and-running, and how to embark on a program of observation.

0-521-00790-9 Pb $30.00

Celestial Objects for Modern Telescopes

Practical Amateur Astronomy, Volume 2

Michael A. Covington

Covers both traditional and novel aspects of studying the night sky using the latest modern resources available to today's astronomer.

0-521-52419-9 Pb $30.00

Worlds Beyond

The Thrill of Planetary Exploration as Told by Leading Experts

S. Alan Stern, Editor

A fascinating collection of essays by leading planetary scientists who explore the planets that captivate them.

0-521-52001-0 Pb $21.00

The Observing Guide to the Messier Marathon

A Handbook and Atlas

Don Machholz

Contains over 90 easy-to-use star maps and provides tips for a successful night of observing with a small telescope or binoculars.

0-521-80386-1 Hb $25.00

Out of the Blue

A 24 Hour Skywatcher's Guide

John Naylor

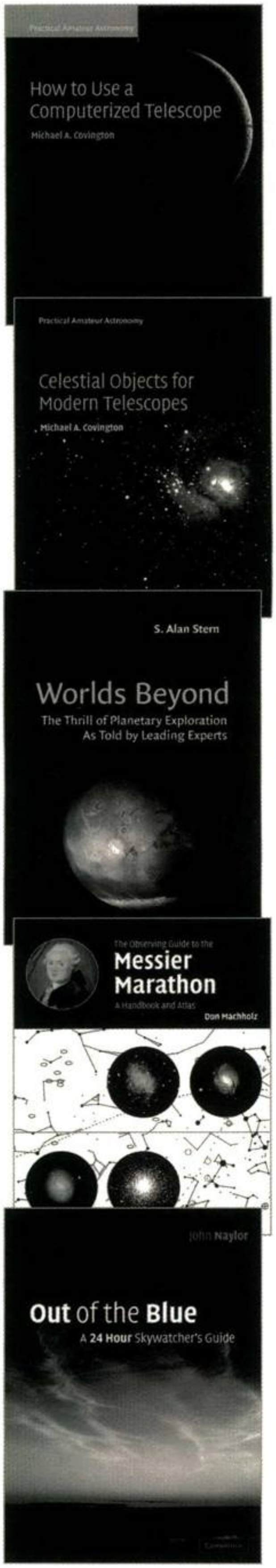
Offers practical advice about where and when you can expect to see, with the naked eye, natural phenomena in both the night and day sky.

0-521-80925-8 Hb $35.00

At better bookstores

CAMBRIDGE
UNIVERSITY PRESS

us.cambridge.org/astronomy

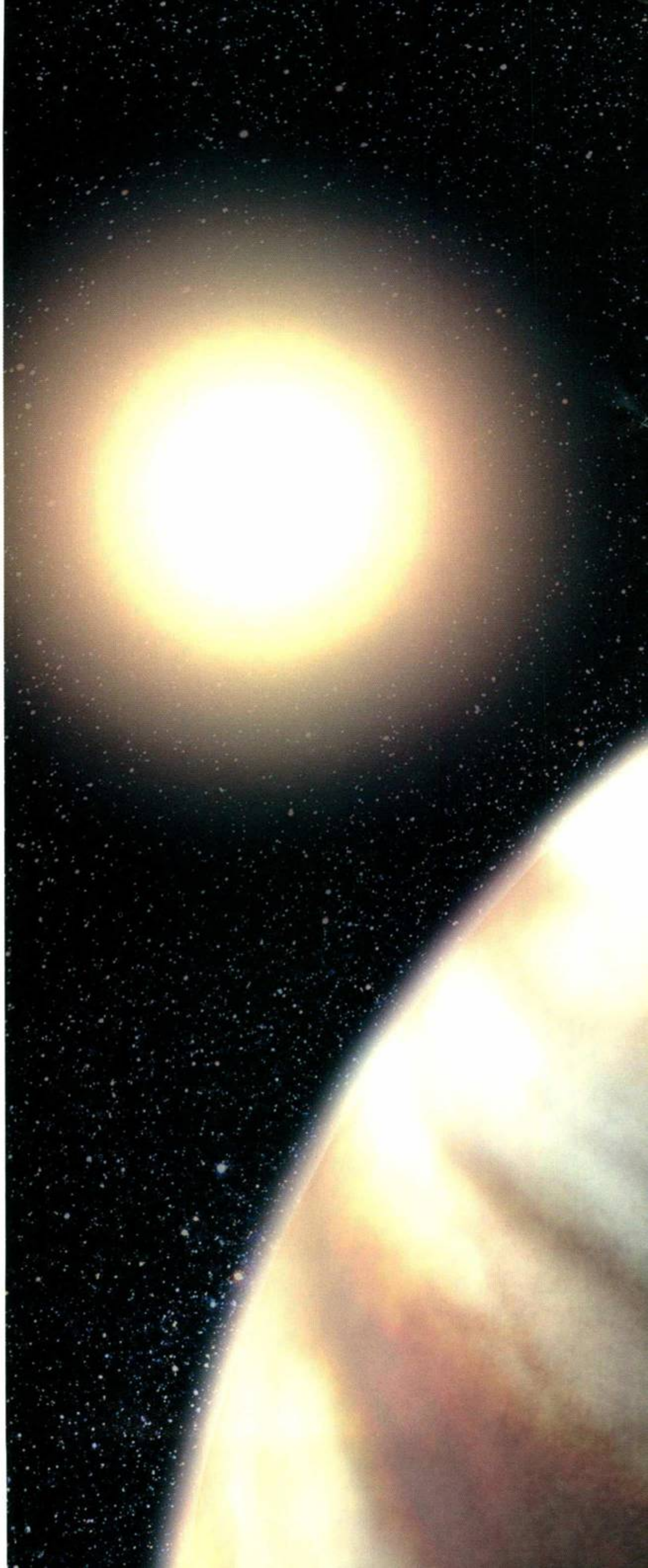

Practical Amateur Astronomy
How to Use a Computerized Telescope
Michael A. Covington
Practical Amateur Astronomy
Celestial Objects for Modern Telescopes
Michael A. Covington
S. Alan Stern
Worlds Beyond
The Thrill of Planetary Exploration As Told by Leading Experts
The Observing Guide to the
Messier Marathon
A Handbook and Atlas
Don Machholz
John Naylor
Out of the Blue
A 24 Hour Skywatcher's Guide

Narrowing the Field

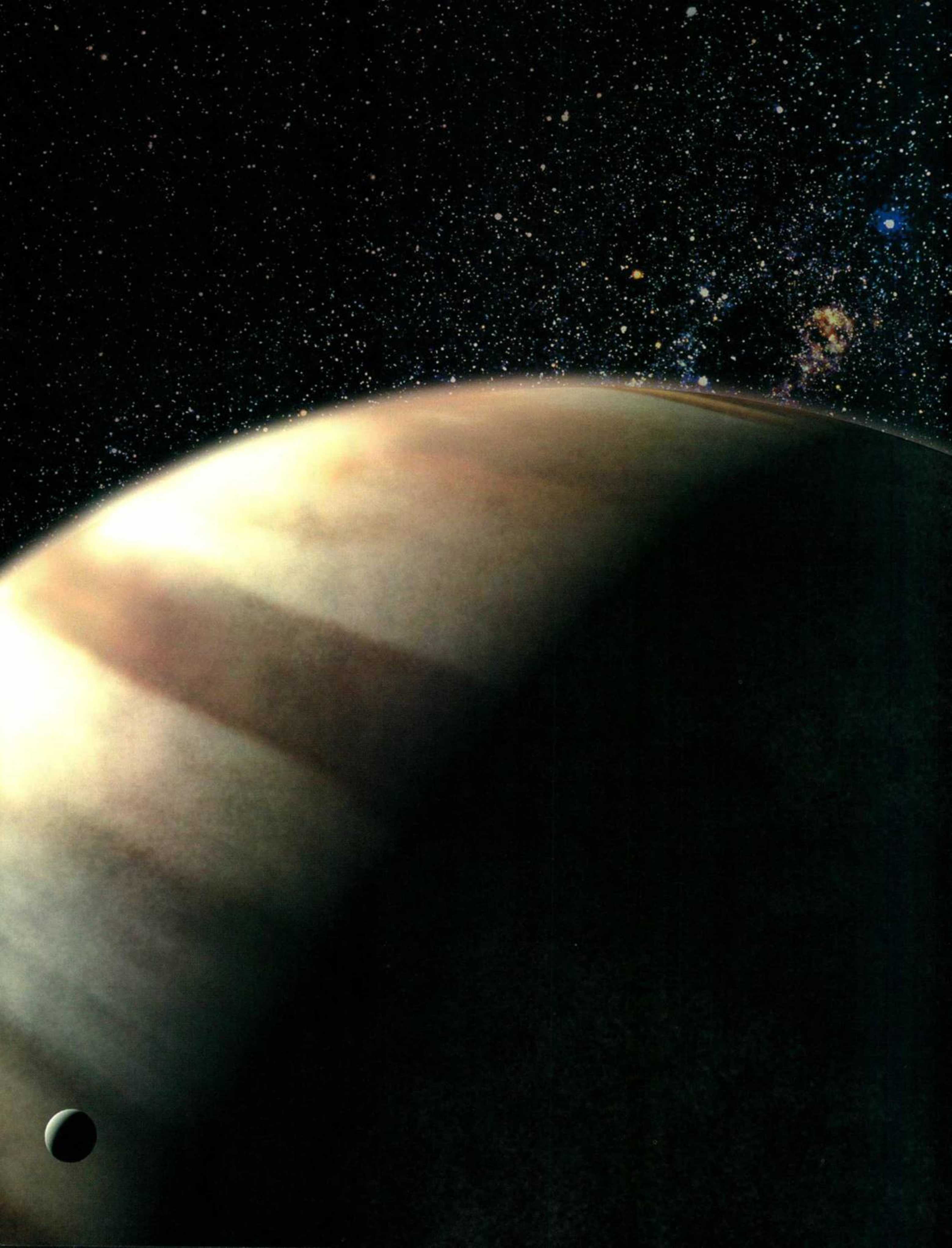
Are astronomers close to finding other Earths in distant solar systems?

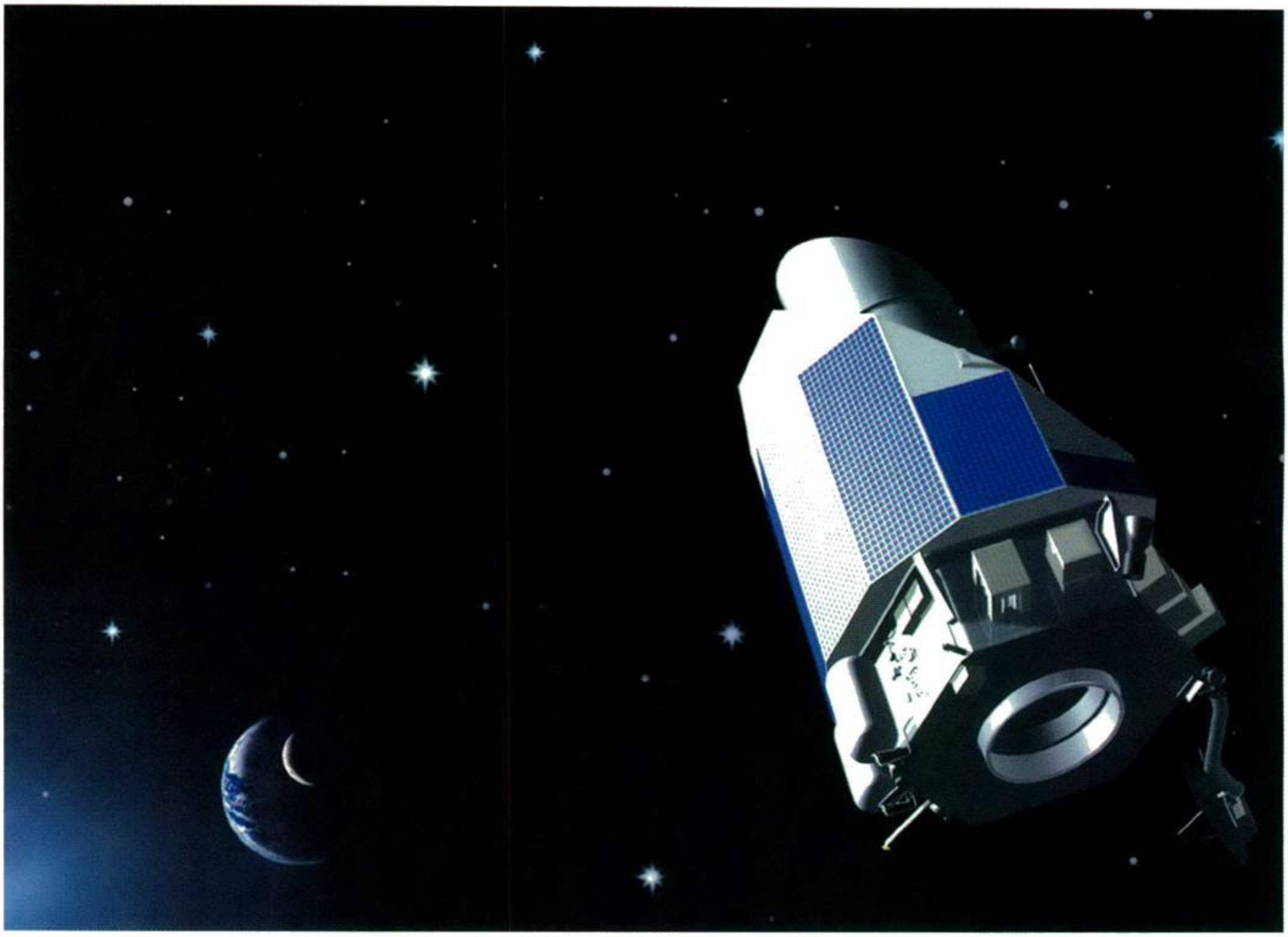
by John Armstrong

Life may be difficult to define, but we tend to recognize it when we see it. In the late 17th century, when Antony van Leeuwenhoek first observed his tiny animalcules in rainwater, their motions within the fluid revealed their true nature — miniscule protozoa, thriving with life. Since then, as scientists explore the Earth, they find all sorts of microscopic organisms. Life thrives in the extreme cold of Antarctica, the boiling water of Yellowstone's hot springs, and even miles below Earth's surface. The search for life also extends to the



The first extrasolar planet with a measured atmosphere, discovered by astronomer David Charbonneau in November 2001, reflects light from its parent star in this illustration. The sunlike star, HD 209458, lies 150 light-years away in the direction of the constellation Pegasus. The planet's atmosphere betrays a strong presence of sodium. G. Bacon, STScI





NASA's Kepler spacecraft, slated for launch in 2006, will carry a photometric telescope to search for earthlike planets in the galaxy. NASA

other planets in the solar system. Mars and Jupiter's moon Europa are the most likely candidates, but beyond the solar system, planets orbiting other stars may hold life.

Recognizing the absence of extraterrestrial life seems to be a bigger problem. Despite many probes and experiments designed to detect life, scientists still debate the possible existence of it on Mars. In 1996, the discovery of controversial biological tracers in the martian meteorite ALH84001 marked a renewed interest in looking for life on the Red Planet. But the closer we look, the more we argue whether or not there is life on Mars.

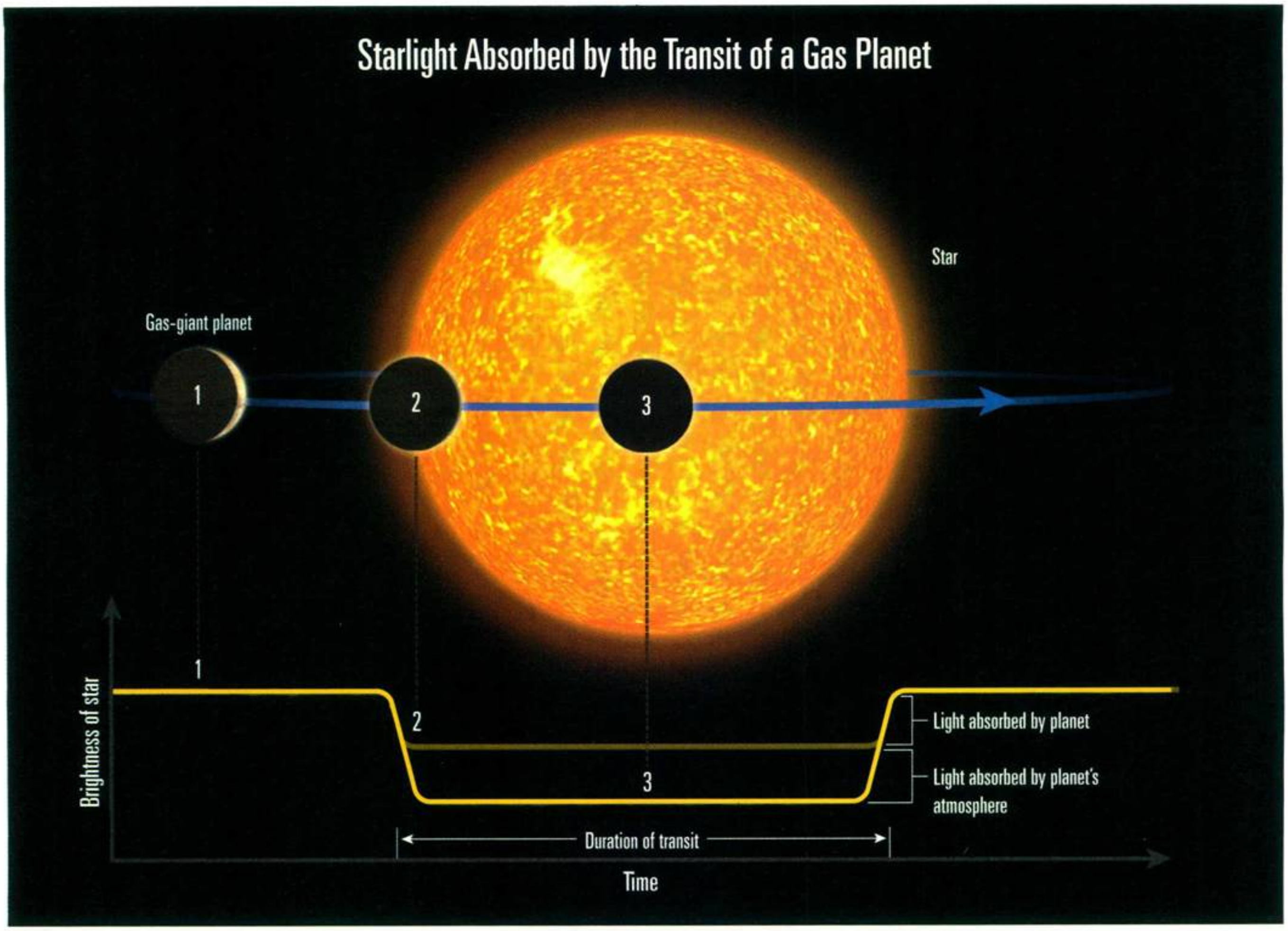
And what about beyond our solar system? During a 50-year search, SETI, the Search for Extraterrestrial Intelligence, has uncovered no artificial signals from another planet, and despite more than 100 newly discovered planets around other stars, there is no evidence for life beyond our solar system. The best astronomers can do is stare at pinpricks of light in an attempt to milk every last drop of information about the planets' properties. So far, astronomers have only discovered massive, and presumably sterile, Jupiter-like planets, most orbiting closer to their parent star than Mercury orbits the sun. That doesn't mean earthlike planets aren't out there, but unless someone starts broadcasting an alien version of "I Love Lucy" across the void, the chances of seeing them with today's instruments are slim.

But if "they" are out there, and if their technology is only a few decades more advanced than our own, they may already know about us. Even ignoring the recent technological riot of electromagnetic noise, our planet reveals subtle hints in the radiation we reflect and emit: hints to our atmosphere's constituents, clues to the chemistry that dominates the cycles of our environment, and even evidence for the existence of life itself.

These clues are imprinted on our star's light every time Earth crosses in front of the sun. Some of the light from the sun passes through our atmosphere, and the constituents therein absorb some of the energy, writing their signature on the sun's spectrum as it speeds out of the solar system. Our planet also reflects the light of the sun, and the conditions in our atmosphere — the dust and clouds, ice and snow — change the amount of light we reflect. Finally, Earth emits its own infrared energy, carrying information about the temperature of the planet. The atmosphere absorbs some of this light as well, encoding more data about the state of Earth. All of this information is packaged in sunlight and sent to the far reaches of the galaxy. Anybody with sufficient interest, and advanced enough technology, could receive this and unlock the secret of Earth.

Hayseed in a Haystack

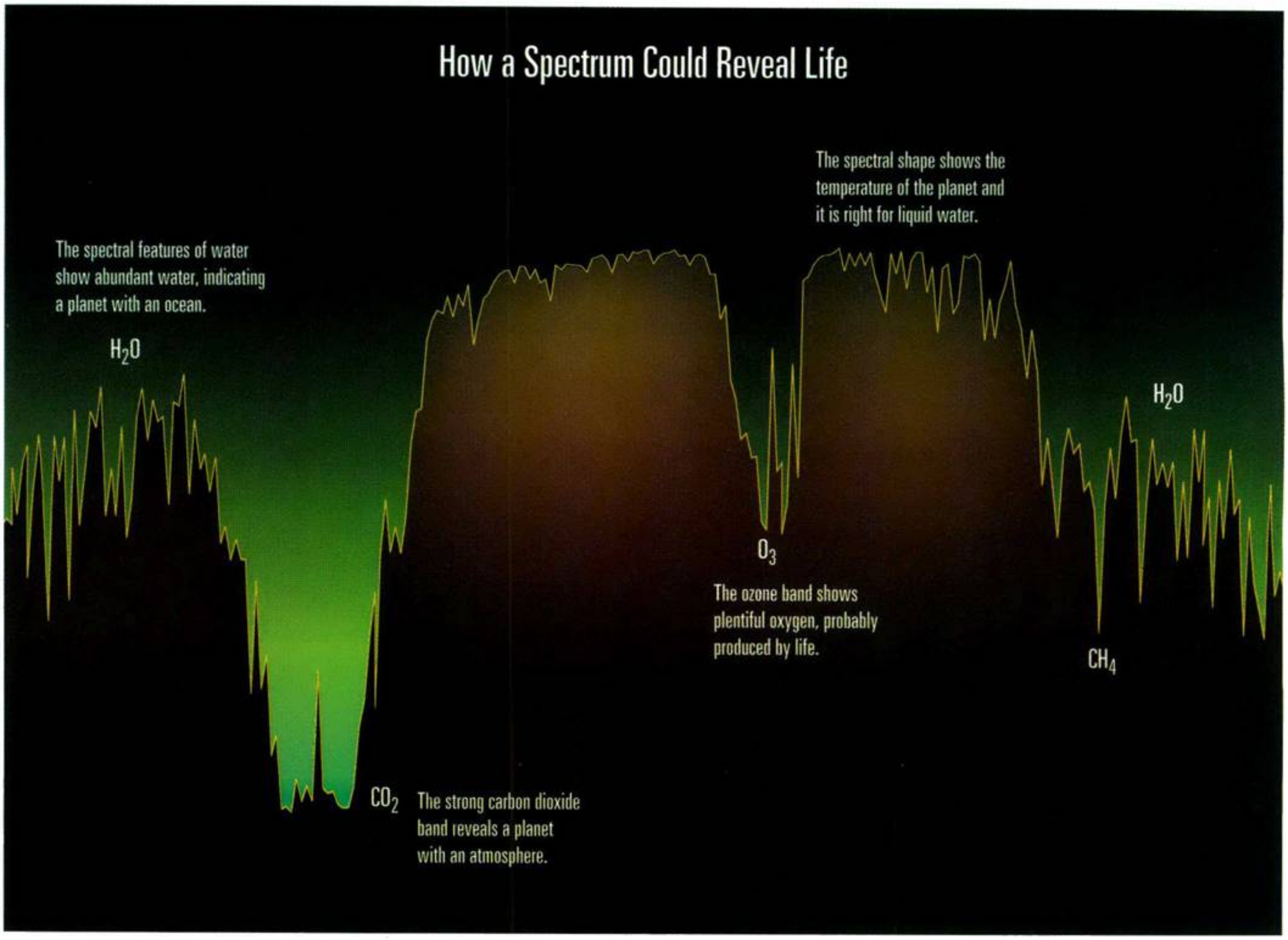
Finding the hint of Earth in this sea of starlight presents a seemingly gargantuan task. The dimming of the light due to Earth passing in front of the sun is one part in 10,000. The tiny effects due to the presence of Earth's atmosphere are less than a millionth the total light of the sun. Forget about a needle in a haystack; it's more like looking for a hayseed in a haystack. But the information about our Earth is there, tangled in the starlight, for anyone to find.


Starlight Absorbed by the Transit of a Gas Planet
Star
Gas-giant planet
1
2
3
Brightness of star
1
2
3
Light absorbed by planet
Light absorbed by planet's atmosphere
Duration of transit
Time

How to Recognize Properties of Planets

Property	Implication for life	Technique
Orbit characteristics (radius, eccentricity, etc.)	Existence of planet in habitable zone	Astrometry, radial velocity, nulling interferometry
Mass	Ability to retain atmosphere	Astrometry, radial velocity
Radius	Density and surface gravity	Transit photometry, direct detection
Combination temperature, radius, albedo	Ability to support liquid water, presence of greenhouse effect	Direct detection in infrared
Atmospheric composition (major gases)	Existence of atmosphere (CO_2), presence of water (H_2O), suggestions of life (O_3, CH_4)	Direct detection with low resolution infrared spectroscopy
Combination of radius, albedo	Density, surface/cloud properties	Direct detection in visible light
Atmospheric gases (minor gases)	Confirmation of life (CH_4, N_2O, O_2 via A-band), atmospheric structure via line profiles	Direct detection with high resolution imaging spectroscopy in visible light/infrared
Presence of moons	Presence of tides	Direct detection with high resolution imaging
Surface features and composition	Existence of oceans and continents	Direct detection with high resolution imaging

How a Spectrum Could Reveal Life



And back on Earth, our own scientists have made the first tentative steps toward detecting such signatures of life from other planets around nearby stars. Recently, David Charbonneau, Millikan Postdoctoral Scholar at Caltech, and his colleagues announced the detection of sodium in the atmosphere of an extrasolar giant planet orbiting the star HD 209458. The group used the Hubble Space Telescope to measure the minuscule influence of the planet's atmosphere on the starlight as it crossed the disk of its parent star. While most of the star's light is unaffected by this distant eclipse, some of the light passes through the planet's atmosphere. Imprinted upon this light is information about the atmosphere's constituents. By carefully observing the star before, during, and after transit, the researchers teased out the tiny effect.

"We went to look for sodium and we found it," says Charbonneau, "but now we can use it to probe the atmosphere." For example, he says, they detected less sodium than expected. This could be due to a lack of sodium, or perhaps something obscures the deeper reaches of the atmosphere, reducing the observed influence of the sodium. "This would be due to clouds. On Earth, they're made of water, but on these planets there might be more exotic species," says Charbonneau, like clouds made of magnesium silicates. "We start to see all the exciting molecular chemistry we see in our own solar system."

This, coupled with a measurement of the radius of the planet during the transit, represents a fundamental shift in extrasolar planet research. "For the first time," says Charbonneau, "we have the mass and the radius of the planet."

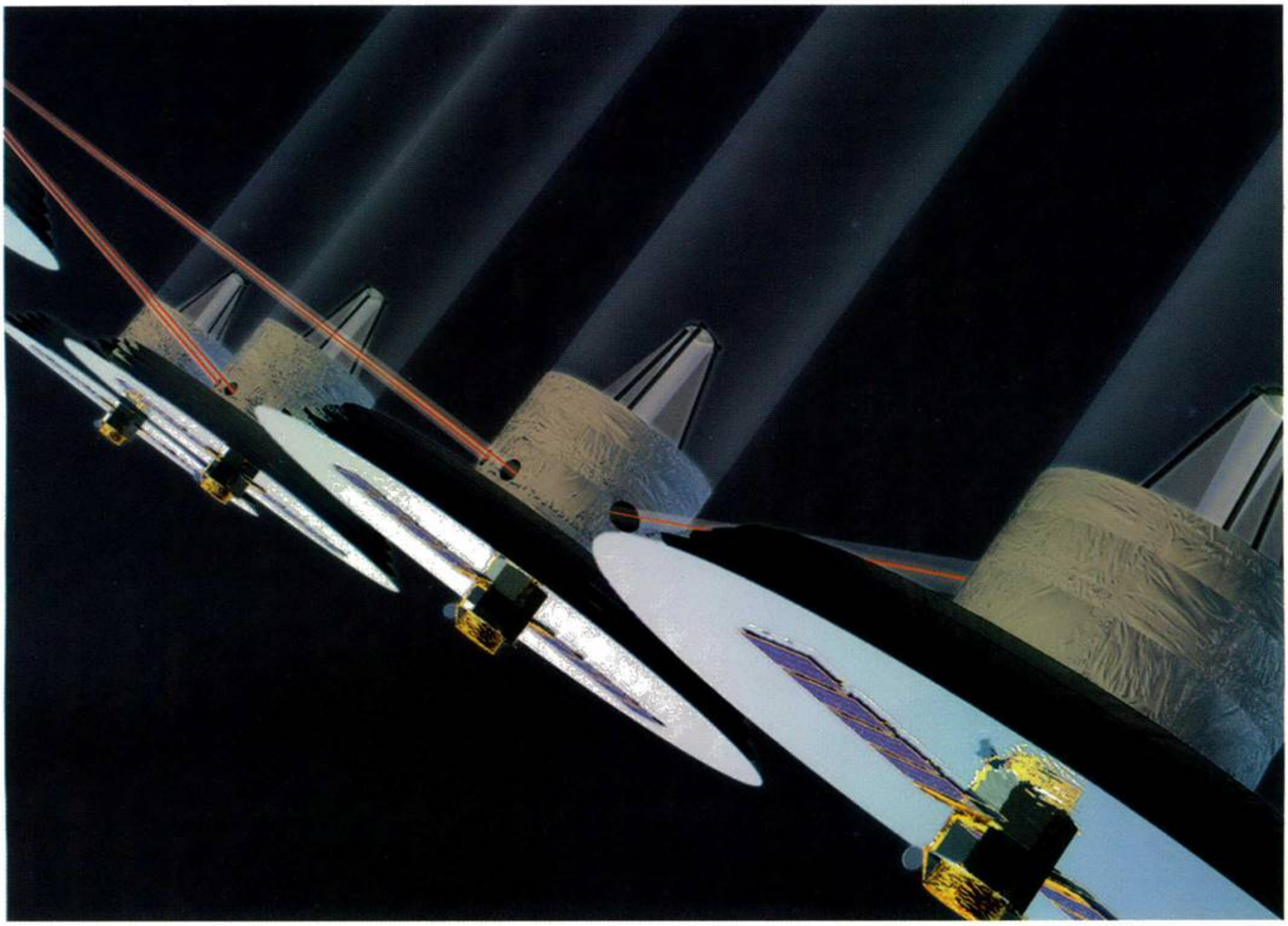
Until recently, all researchers could say definitively about extrasolar planets was that they exist. The dominant detection method gave a lower limit on the planet's mass, as well as orbital parameters like the planet's period and eccentricity. While this provided a wealth of data for scientists studying dynamical properties of such systems, planetary scientists used to the abundance of detail provided by spacecraft missions were slow to be impressed.

Into a Totally New Era

Enter the planet orbiting HD 209458, with known mass and radius, and therefore a known density. Adding to that are measurements of a dominant chemical component, sodium, and information about the reflectance of the atmosphere itself.

Researchers found themselves looking at not just an extrasolar planet, but a planet 0.7 times the mass and 1.3 times the size of Jupiter, giving it a density of about 40 percent that of water. And it contained sodium. In short, the planet around this star began to develop a list of known properties comparable to the massive planets of our own system, like Jupiter and Saturn. They could only wonder what they would find next.

With that type of information, scientists begin to explore more details about how these planets were formed. For that, the density is particularly helpful. "If the planet moves in slowly, after it collapses, it won't puff back up," says Charbonneau. "But if it moves in quickly, it will contract more slowly since it is in a hotter environment." The result is a massive, Jupiter-like planet forming a great distance from the star and migrating in quickly, thus maintaining a lower density, a confirmation of some formation models.



Terrestrial Planet Finder, a NASA craft to be launched in 2011, will be an interferometric telescope designed for planet searching. NASA

However, as Sara Seager of the scientific staff in the Department of Terrestrial Magnetism at the Carnegie Institution of Washington is quick to point out, it is only one planet. "At the moment, this is a 'one planet, one method' problem," says Seager, stressing that she doesn't want to downplay the importance of the discovery. "So far, they've only looked at one line out of the entire spectrum." She goes on to suggest that unless more planet transits like this are found, and more components of the atmosphere are measured, the data will remain somewhat anecdotal.

"One interesting point is that we don't really know much about them," says Seager. We know the minimum mass, and the orbital characteristics, but, "in terms of their physical characteristics, we don't know much."

Charbonneau and others are attempting to remedy this with further observations of HD 209458. "We can now get the precision we need to gather data across the visible spectrum," says Charbonneau, to look for features from other molecules like water. However, this is still only applied to one star, and researchers anxiously await another transit detection.

While waiting for more data, Seager and others use our own solar system to work out the models used to examine the data from systems like HD 209458. "The exact way that light varies tells us about the atmosphere," she says. For example, clear atmospheres reflect starlight differently than cloudy atmospheres. For her Ph.D. dissertation, Seager studied the effects of starlight on extrasolar giant planets using Jupiter's atmosphere as a model. But, since Jupiter is in the outer solar system, Seager explains, scientists have never seen it from the same perspective as they see the extrasolar planets. In that sense, Venus is a better model.

"Nature was kind," says Seager, "giving us a planet like Venus in the inner solar system." Venus has a thick atmosphere and orbits the sun interior to the Earth's orbit. Therefore, it goes through a full sequence of phases, from fully illuminated, to half lit, to invisible, just like the phases of the moon. Similarly, extrasolar giant planets orbiting other stars go through a complete set of phases. The trick for theorists is trying to understand what an atmosphere like Jupiter's would look like going through phases like Venus, with the signal swamped by the starlight of the parent star.

And with that in mind, Seager, Charbonneau, and others await the launch of other instruments to help further their goals. Several ground-based telescopes, such as STARE (Stellar Astrophysics and Research on Exoplanets) and Charbonneau's own Palomar Planet Search Telescope, patiently search for more transits of extrasolar giant planets. Once identified, more sensitive instruments like Hubble can be used to measure the atmospheric component.

Other space-based telescopes are being readied for deployment. Two missions, the Canadian MOST (Microvariability and Oscillations of STars) and the Danish MONS (Measuring Oscillations of Nearby Stars) are designed primarily to study astroseismology, the tiny fluctuations in starlight due to oscillations of the stellar surface. However, these devices will have the

precision to look for extrasolar planet transits as well. Another mission, the French COROT (COnvection, ROtation and planetary Transits), will also search for extrasolar planets. These small satellites, however, are designed to explore only the brightest stars, hampering their ability to survey a large number of potential candidates.

With the exception of COROT, none of these missions are specifically designed to search for planets. The next step is finding and characterizing planets with masses much less than Jupiter and Saturn. In December 2001, NASA announced support for the Kepler mission, a larger orbiting telescope scheduled for launch in 2007. This mission plans to push the size limit of detection into the realm of planets like Venus and Earth. In fact, according to the Kepler group, if earthlike planets are common, as many as 50 will be detected by mission's end.

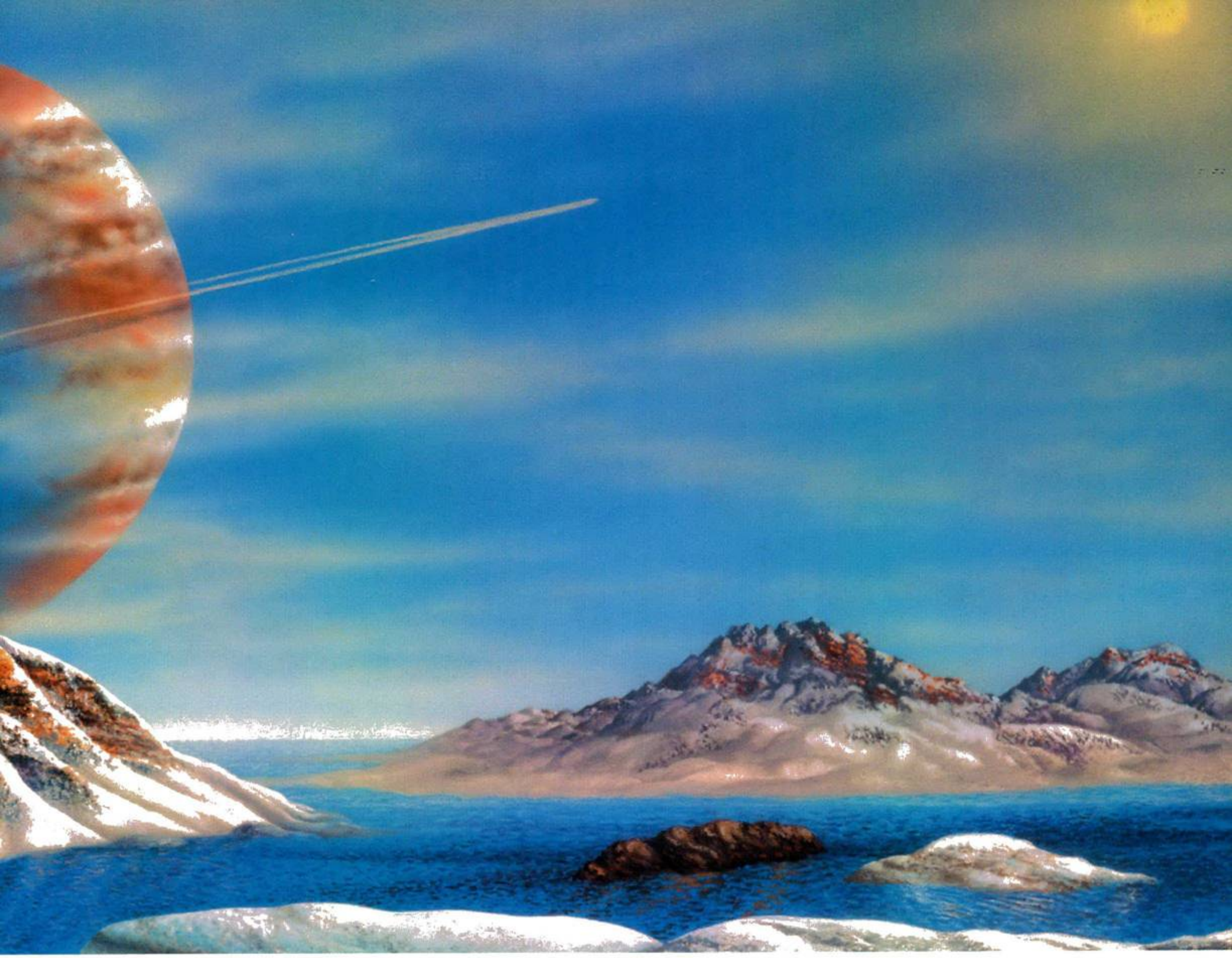
Researchers across the field of extrasolar planets agree that Kepler-style missions are the next logical step. "The extrasolar planets are currently known on an anecdotal basis," says Greg Laughlin, extrasolar planet researcher and assistant professor at the University of California, Santa Cruz. "I think of them as sort of individual stories. By getting a huge census you start to look at an entire population." And while Laughlin thinks the current techniques for finding extrasolar planets such as Doppler radial velocity measurements won't be supplanted "any time soon," he stresses, "You are just not going to find earthlike planets with the radial velocity technique."

All of these instruments rely on measurements of the starlight as the planet passes over the face of the parent star, giving a measurement of the size of the planet, and, in the case of larger planets with thick atmospheres, some indication of the atmospheric conditions. These types of measurements will give the frequency of earthlike planets, but a telescope of this type designed to detect the effect due to such a small planet's atmosphere seems completely unrealistic.

"We could know about the incidence of earthlike planets by 2010," says Charbonneau, but Kepler will not help study the effects of the atmosphere during a transit of earthlike planets. And even a larger telescope similar to Kepler probably won't be able to get at that kind of information, according to Charbonneau. "Such a telescope does not seem realistic," he says, "but Kepler will determine the frequency of earthlike planets and set the scale for such detections."

Enter Space Interferometry

What's required is a different type of space-based instrument designed to cancel out the light of the parent star and allow researchers to directly detect the light from the planet itself, and from that light extract a spectrum. And such an instrument is



Sunlike stars like HD 222582b may harbor planets with plentiful water and atmospheres that resemble Earth's. Lynette Cook

not science fiction. The NASA plan for the Terrestrial Planet Finder (TPF) envisions a fleet of free-flying space-based telescopes circling the sun near the orbit of Jupiter. These separate satellites would fly in formation and use the technique of nulling interferometry to remove the light from the central star by interfering the light from the separate telescopes, allowing detection of the relatively feeble reflected and infrared light from the planets to shine through. Given a sensitive enough instrument, the full spectrum of a planet's atmosphere could be recorded, which would be astonishing.

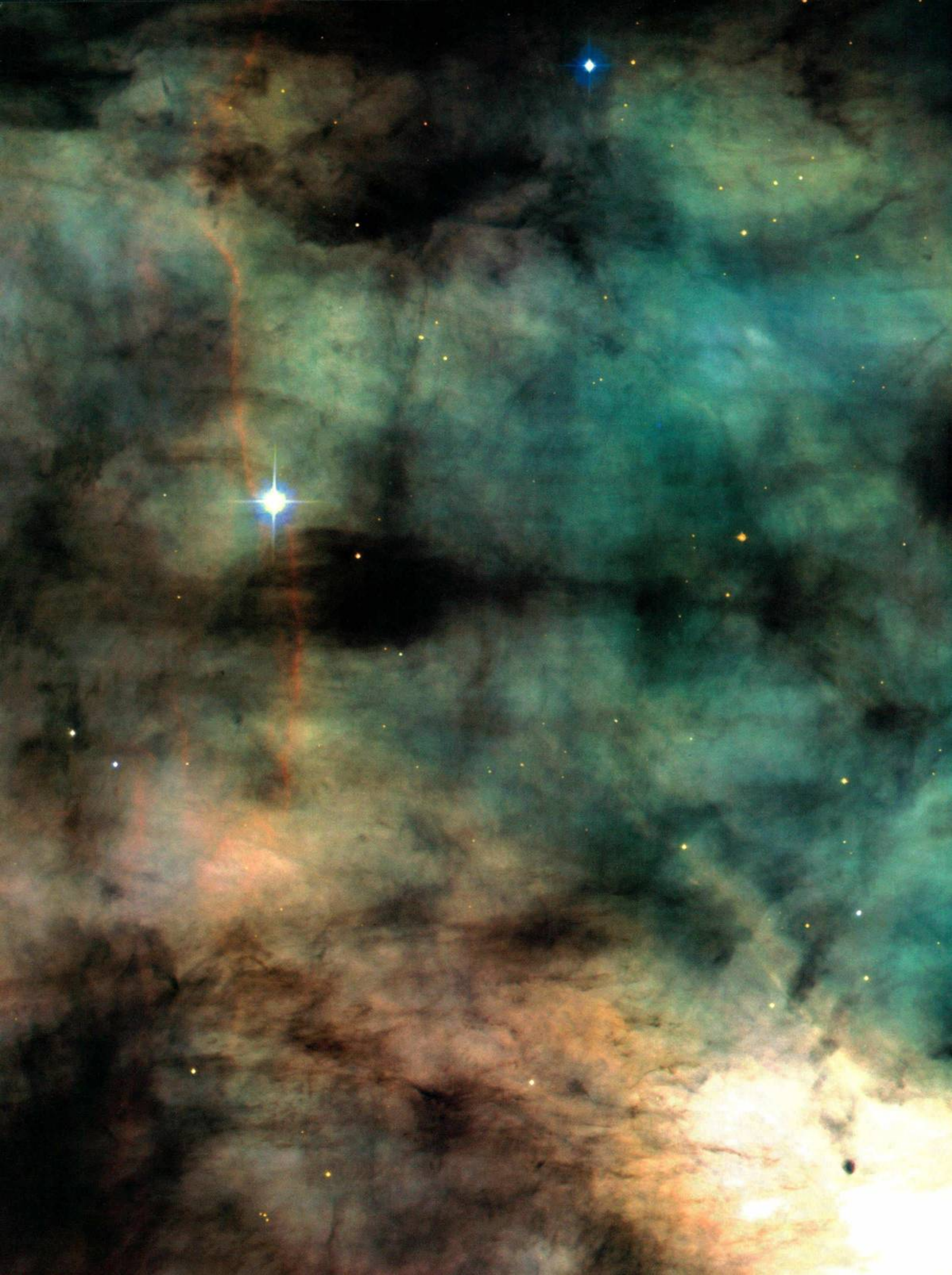
What are we looking for? The key, according to many researchers, is disequilibrium chemistry. Earth's atmosphere, for example, contains a large fraction of oxygen. Left on its own, oxygen reacts quickly with just about everything. Without photosynthesizing plants to constantly replenish it, the atmosphere would be scrubbed clean of oxygen in a short period of time. Sunlight reacts with oxygen to produce ozone, a prominent feature in Earth's atmospheric spectrum. Therefore, the signature of ozone could indicate the presence of life. However, oxygen in Earth's atmosphere, and the organisms that rely on it, has only been around for the last two billion years, leading some researchers to suggest that other tracers like methane would also be good proxies for life.

While the technological hurdles to getting such a spectrum are not insurmountable, they may be a long way off. "The technology required to get an earthlike spectrum with enough signal to noise to detect oxygen is not going to be ready for today's undergraduate to work on as a graduate student," says Charbonneau, "but it is certainly something such a person could expect to see in his lifetime."

Seager agrees, noting that the will of the people, rather than the technology, will determine whether such an instrument flies. "TPF is interesting, but it is a science per dollar issue," she says. "Finding an earthlike planet is priceless, but what if we spend $2 billion of the tax payers' money and it doesn't reach its goal? It's just a question of money. The technological challenges can be overcome."

And it is missions like Kepler that will fuel the public debate. By 2010, we should know if earthlike planets are common or rare, and whether or not the chances are good that anyone is out there, looking down on us. ▣

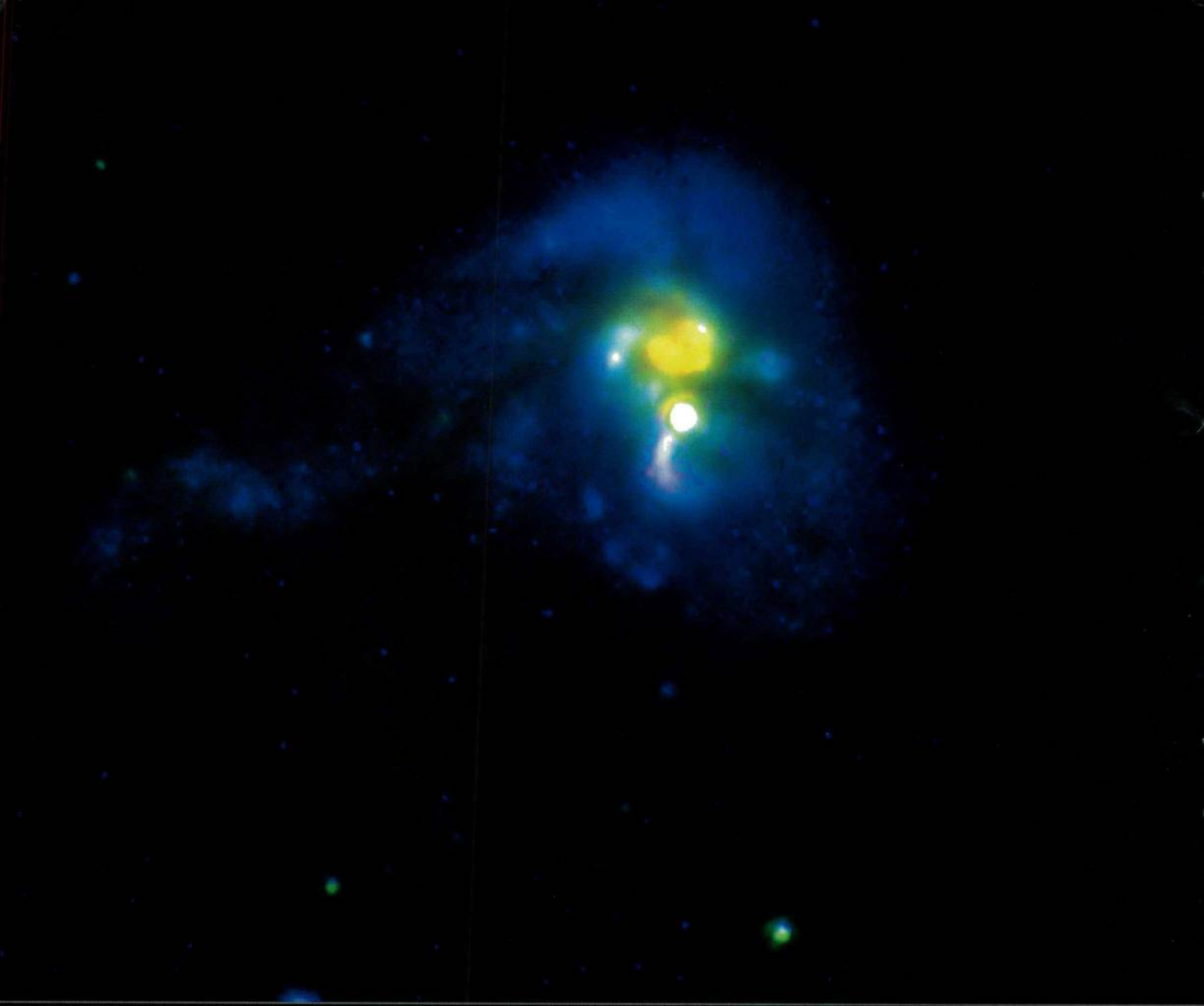
John Armstrong is an astronomy graduate student at the University of Washington in Seattle.



New Views of the Cosmos

More than a decade into its mission, Hubble continues to lay bare the beauty of our universe.

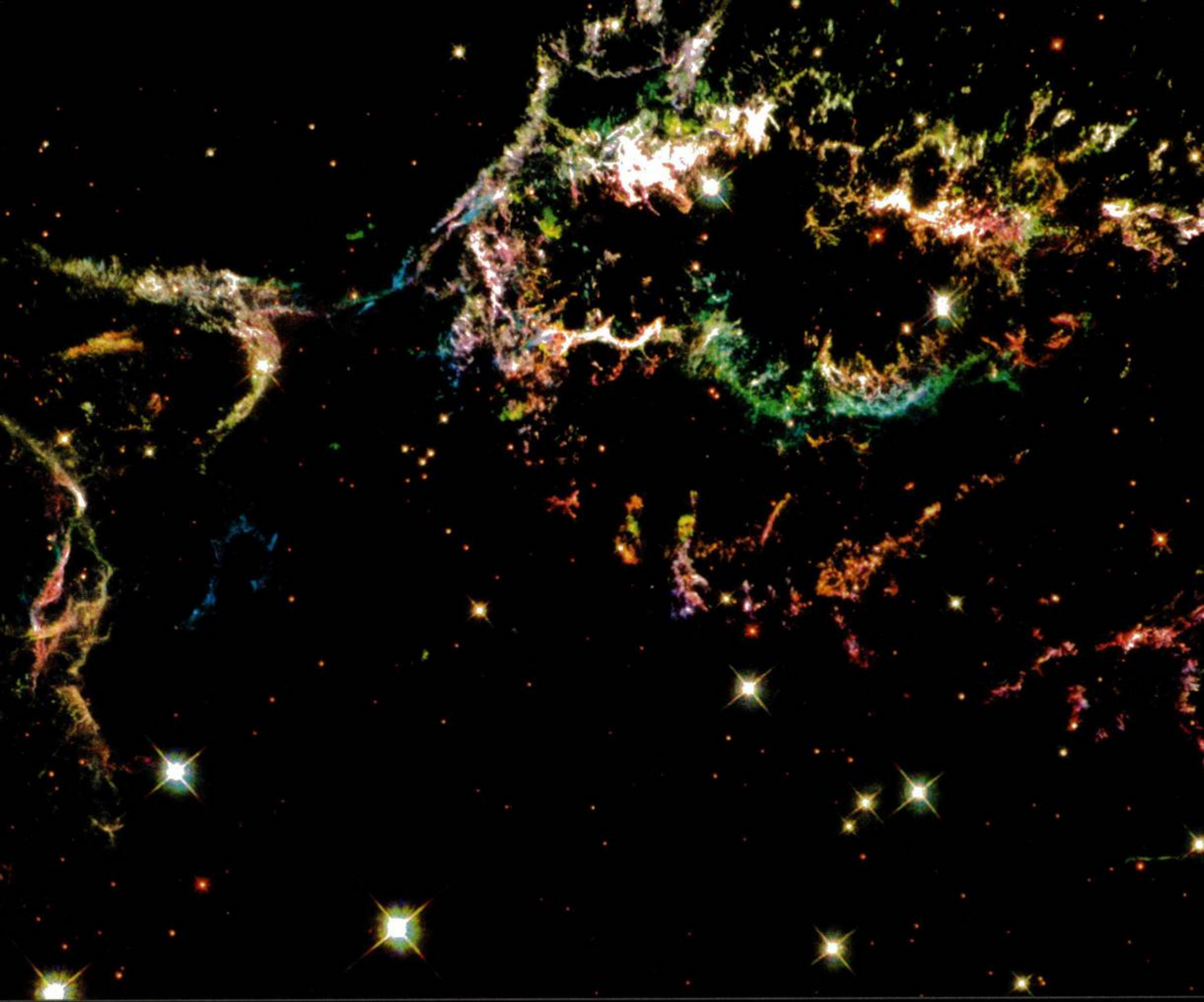
by Elesa Janke



Above, left: The ACS and NICMOS combined to capture four colliding galaxies, called IRAS 19297–0406. NASA, ESA, and the ACS and NICMOS science teams

Above: Although now a second banana, WFPC2 still performs admirably. This 2002 image reveals debris in the Cassiopeia A supernova remnant. NASA and the Hubble Heritage Team (STScI/AURA)

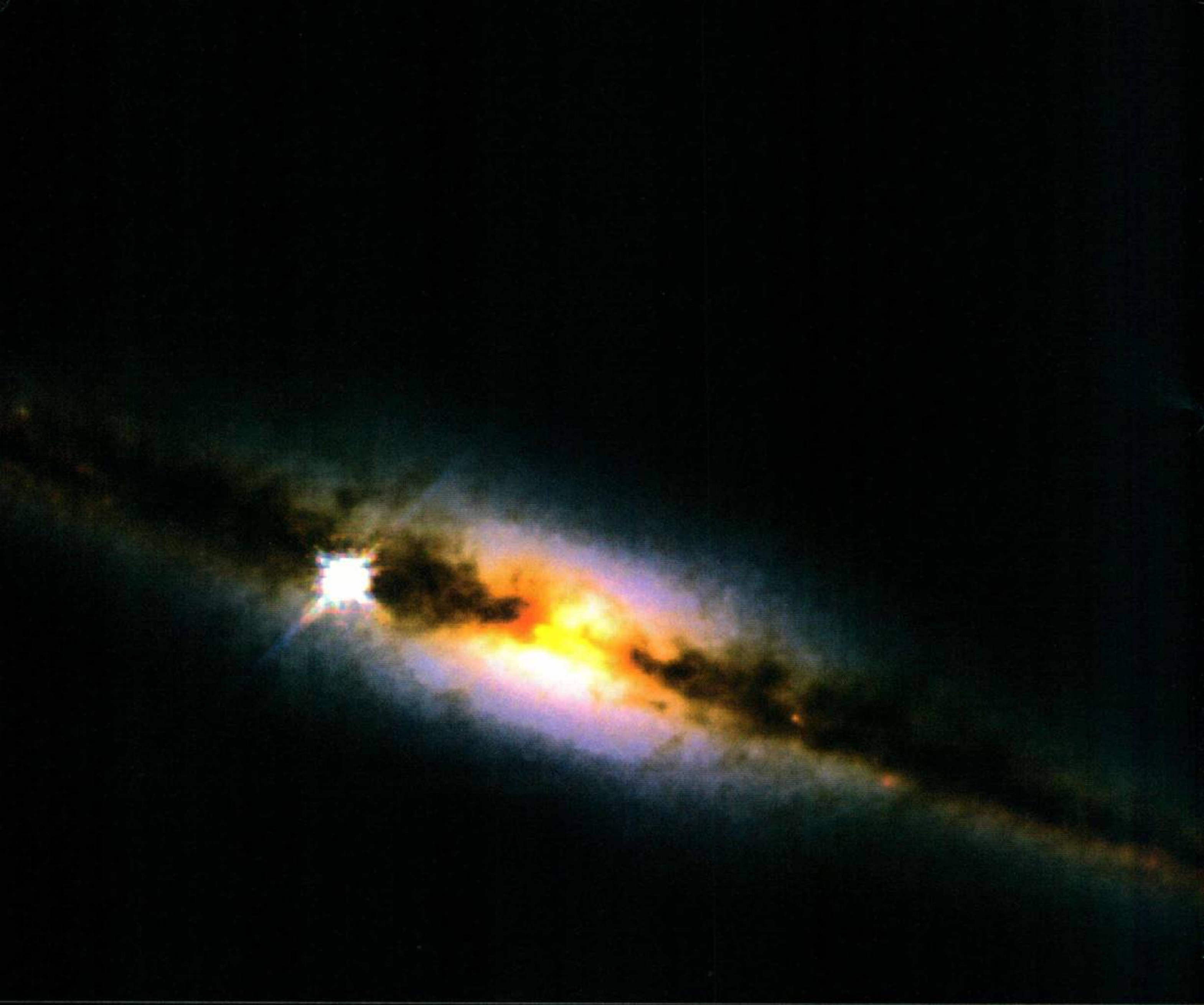
Previous pages: Tendrils of gas and dust weave through the Omega Nebula (M17) in this ACS image. NASA, ESA, and the ACS Science Team



Since 1990, NASA's Hubble Space Telescope has wowed astronomers and non-astronomers alike with its unprecedented views of the universe, showing us what the cosmos looks like beyond the limited views of earthbound telescopes. But now it seems that the past twelve years of images are only the icing on the cosmic cake. In recent months, Hubble's eyesight has improved tenfold with the addition of the new Advanced Camera for Surveys (ACS). Installed in early March 2002, the new camera has ten times more discovery power than Hubble's other main camera, the Wide Field and Planetary Camera 2.

"Our team of scientists and engineers on the ground and the astronauts in space once again did the impossible," stated Ed Weiler, Associate Administrator for Space Science at NASA. "Hubble was not only given a major overhaul, its new camera has already shown us that, even after 12 years of great science and astounding images, we haven't seen anything yet."

Astronauts installed the new camera during the fourth Hubble servicing mission, which

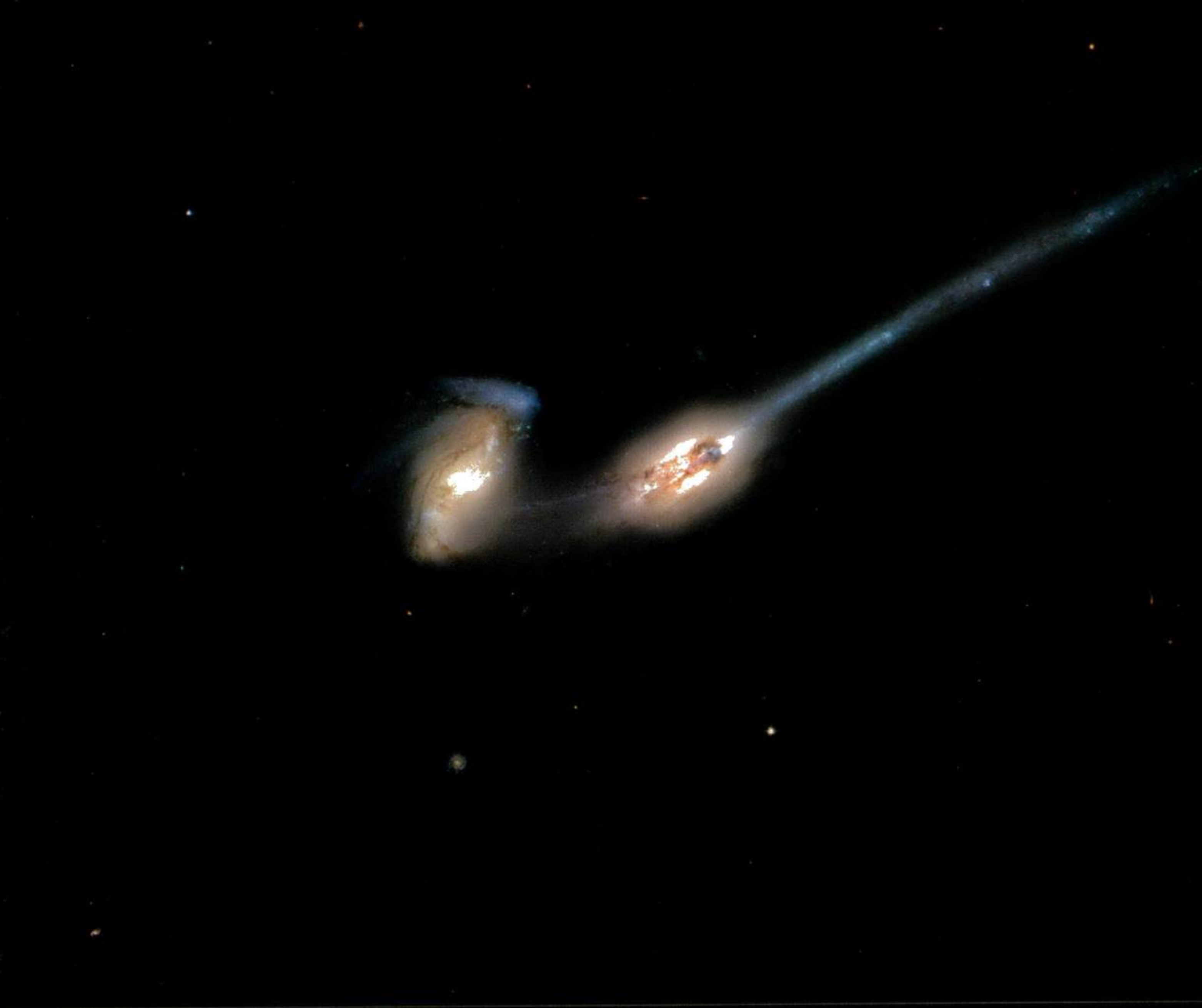


required five of the most difficult spacewalks ever completed. In addition to the ACS, the crew also installed a new power unit, new solar arrays, and an experimental cooling unit for Hubble's infrared camera, NICMOS. According to the Hubble team, the space telescope is now operating as if it was brand new, instead of more than twelve years old.

"The ACS will let us obtain the deepest image of the universe for the foreseeable future," explains Garth Illingworth of the University of California's Lick Observatory, deputy leader for the camera team.

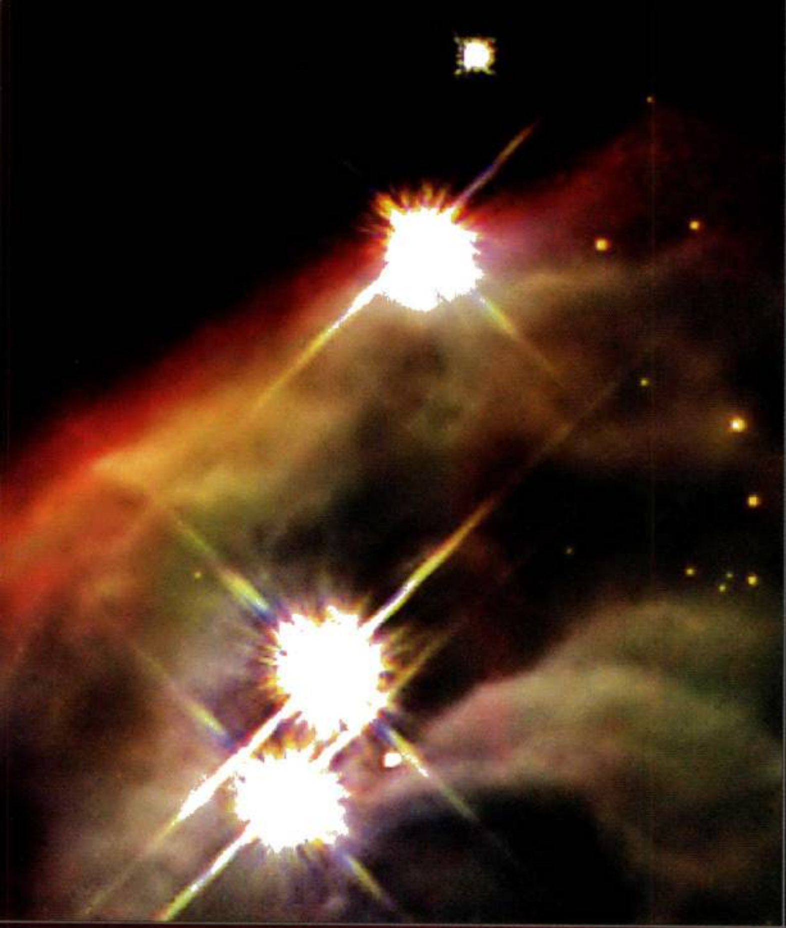
The first images, released in April, revealed the first signs of Hubble's improved capabilities. The detail and clarity that the ACS camera provides are astounding, with panoramic views and a crispness comparable to that of a wide-screen movie. Now, with new images being unveiled on a regular basis, our views of the universe are beginning to expand even beyond the hopes of astronomers.

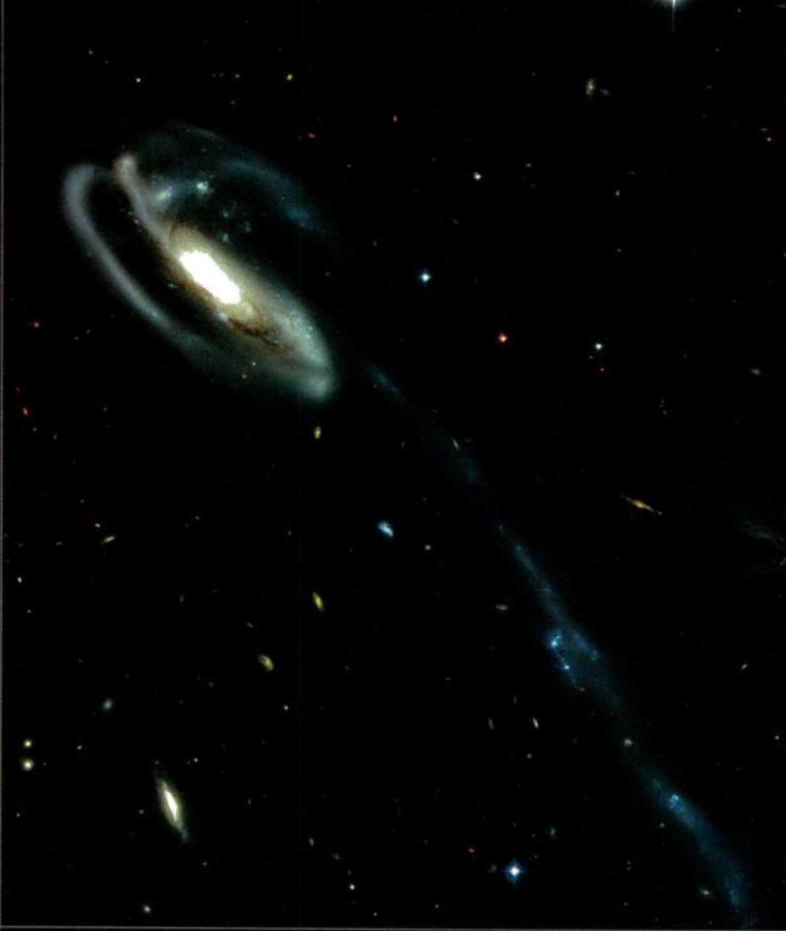
"ACS will allow us to push back the frontier of the early universe. We will be able to enter the twilight zone period when galaxies were just beginning to form out of the blackness following

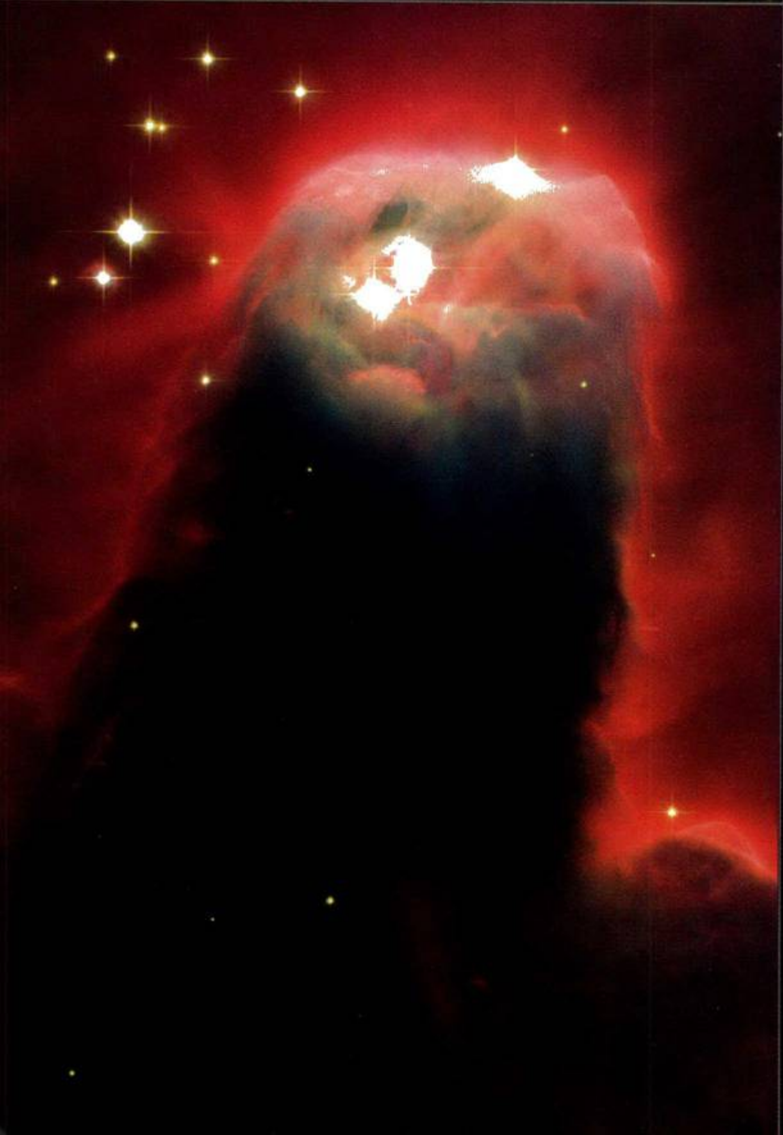


Above: NICMOS captured the golden infrared glow from a ring of newborn stars in the heart of the edge-on spiral NGC 4013. NASA, ESA, and the NICMOS Science Team

Above, right: Massive new clusters and tails of debris highlight this ACS view of the colliding galaxies known as the Mice (NGC 4676). NASA, ESA, and the ACS Science Team







the cooling of the universe from the Big Bang," says astronomer Holland Ford of Johns Hopkins University, lead scientist in the camera's seven-year development.

To see Hubble's latest images, take a look at our photo gallery on these pages, and check out our website at Astronomy.com, where you will find the most up-to-date news and photos as they become available.

Above, left: Infrared light from a host of faint young stars pierces the dense dust layers at the tip of the Cone Nebula (NGC 2264).

NASA, ESA, and the NICMOS Science Team

Left: The ACS snapped a wider portrait of the Cone, revealing its aura of hydrogen gas excited by the ultraviolet light of hot stars.

NASA, ESA, and the ACS Science Team

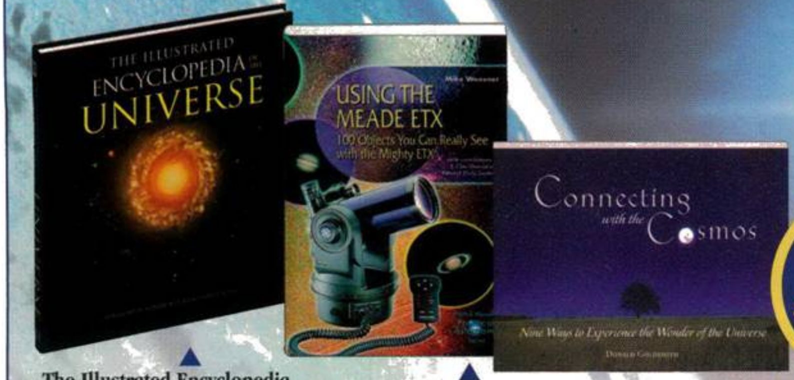
Above: Another galactic collision formed brilliant star clusters and the long debris tail of the Tadpole (UGC 10214), but this ACS image also captured several thousand background galaxies. NASA, ESA, and the ACS Science Team

Explore the cosmos

Choose **3** Books for **$1.99** each

with membership in the **Library of Science®**

VALUES UP TO $109.90

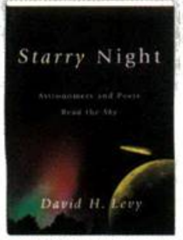

THE ILLUSTRATED ENCYCLOPEDIA OF THE UNIVERSE
USING THE MEADE ETX
100 Objects You Can Really See with the Mighty ETX!
Connecting with the Cosmos
Nine Ways to Experience the Wonder of the Universe
Donald Goldsmith

The Illustrated Encyclopedia of the Universe
Ian Ridpath
3780-9999* ~~$45.00~~ **$3.98**

Using the Meade ETX
Ian Ridpath
3871 ~~$34.95~~ **$1.99**

Connecting with the Cosmos
Donald Goldsmith
3624 ~~$16.95~~ **$1.99**

Publishers' Prices shown **Counts as 2 choices*


Starry Night
Astronomers and Poets Read the Sky
David H. Levy

Starry Night: Astronomers and Poets Read the Sky
David H. Levy
3632 ~~$18.00~~ **$1.99**

KAREN C. FOX
THE BIG BANG THEORY

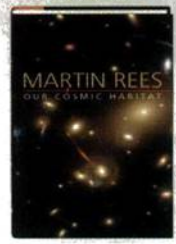
The Big Bang Theory
Karen C. Fox
3640 ~~$15.95~~ **$1.99**

The Future of Spacetime
Stephen W. Hawking
Kip S. Thorne
Igor Novikov
Timothy Ferris
Alan Lightman
Richard Price

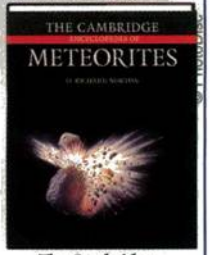
The Future of Spacetime
Stephen Hawking, et al.
3657 ~~$25.95~~ **$1.99**

THE CURVATURE OF SPACETIME

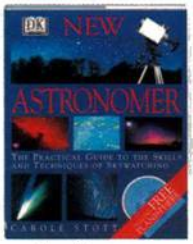
The Curvature of Spacetime
Harald Fritzch
3655 ~~$29.95~~ **$1.99**


MARTIN REES
OUR COSMIC HABITAT

Our Cosmic Habitat
Martin Rees
3715 ~~$22.50~~ **$1.99**


THE CAMBRIDGE ENCYCLOPEDIA OF METEORITES

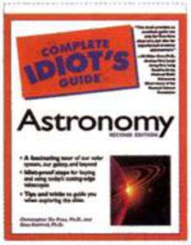
The Cambridge Encyclopedia of Meteorites
O. Richard Norton
3863-9999* ~~$50.00~~ **$3.98**


DK
NEW ASTRONOMER
CAROLE STOTT

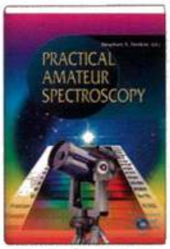
New Astronomer
Carole Stott
3731 ~~$24.95~~ **$1.99**

MARCUS CHOWN
The Universe Next Door

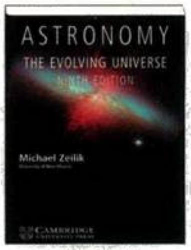
The Universe Next Door
Marcus Chown
3764 ~~$26.00~~ **$1.99**


THE COMPLETE IDIOT'S GUIDE
Astronomy

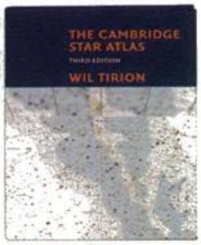
The Complete Idiot's Guide to Astronomy, 2/e
C. DePree & A. Axelrod
3772 ~~$18.95~~ **$1.99**


PRACTICAL AMATEUR SPECTROSCOPY

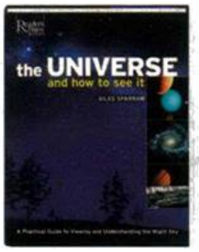
Practical Amateur Spectroscopy
Stephen F. Tonkin
3798 ~~$39.95~~ **$1.99**


ASTRONOMY
THE EVOLVING UNIVERSE
Michael Zeilik

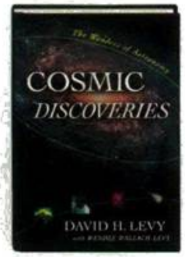
Astronomy: The Evolving Universe, 9/e
Michael Zeilik
3806-9999* ~~$60.00~~ **$3.98**


THE CAMBRIDGE STAR ATLAS
WIL TIRION

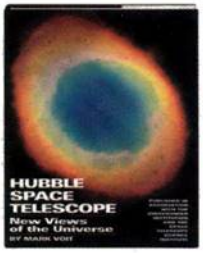
The Cambridge Star Atlas, 3/e
Wil Tirion
3814 ~~$24.95~~ **$1.99**


the UNIVERSE and how to see it

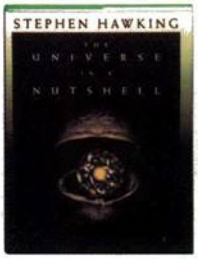
The Universe and How to See it
Giles Sparrow
3822 ~~$32.95~~ **$1.99**


COSMIC DISCOVERIES
DAVID H. LEVY

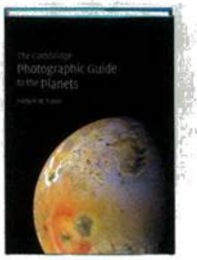
Cosmic Discoveries
D. H. Levy & W. Wallach Levy
3830-9999* ~~$28.00~~ **$3.98**


HUBBLE SPACE TELESCOPE
New Views of the Universe

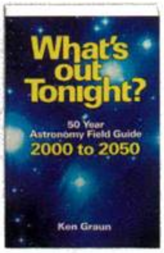
Hubble Space Telescope: New Views of the Universe
M. Voit & R. Maurer
4226-9999* **$3.98**
exclusive hardcover edition


STEPHEN HAWKING
THE UNIVERSE IN A NUTSHELL

The Universe in a Nutshell
Stephen Hawking
3608 ~~$35.00~~ **$1.99**


The Cambridge Photographic Guide to the Planets

The Cambridge Photographic Guide to the Planets
Frederic W. Taylor
3855-9999* ~~$49.95~~ **$3.98**


What's out Tonight?
50 Year Astronomy Field Guide
2000 to 2050
Ken Graun

What's Out Tonight? 50 Year Astronomy Field Guide
Ken Graun
3723 ~~$29.95~~ **$1.99**

www.libraryofscience.net

MEMBERSHIP MADE EASY Membership is easy. Just choose 3 books for $1.99. Send no money now. Your bill, including shipping and handling, plus sales tax where applicable, will come when your membership is confirmed (unless otherwise notified). • **Big Savings:** You keep saving substantially with discounts of at least 20% off and up to 50% off the Publishers' Edition Prices. Also, with your first purchase of one regular selection, you'll earn Bonus Credits you can use to save 50% on any title offered in the club. • **Satisfaction Guaranteed:** If you are not satisfied with your introductory shipment, you can return it within 15 days at our expense. Your membership will be canceled, and you'll owe nothing. • **Great Selections:** Our editors review thousands of possible selections to bring you only the best. We feature quality publishers' editions and special book club editions (full-length hardcover editions sometimes altered in size) available only to club members. Your only commitment is to purchase three books at regular Member's Prices in the next two years. After that you're free to cancel. • **Convenient Service:** At 3- to 4-week intervals (up to 18 times a year), you'll receive a Club Magazine describing the Main Selection and featured Alternate Selections along with a dated Reply Card. If you want the Main Selection, do nothing at all. It will be sent to you automatically. If you prefer another selection, or nothing at all, simply indicate your choice on your member Reply Form and return it by the specified date. A shipping-and-handling charge (and sales tax where applicable) is added to each order. • **Risk-Free Return Privilege:** You'll always have 15 days to decide. If, because of late mail delivery of the magazine, you should receive a book you don't want, you can return it at our expense, and we'll credit your account. *Library of Science®* is a registered trademark of Doubleday Select, Inc. Used under license. All rights reserved. Explore the Universe Annual September 2002 44/X071/RS345

SKYWATCHER'S INN
THE ARIZONA
ASTRONOMY AND
NATURE RETREAT
BED AND BREAKFAST at the
VEGA-BRAY OBSERVATORY
New, modern, and comfortable lodging.
Many **TELESCOPES** from 6 to 20 inches,
computer slewing and **CCD** imaging.
Science museum and planetarium.
DARK SKIES AND SPARKLING DAYS.
47 miles east of Tucson, 28 miles from Tombstone.
Close to many astronomical observatories,
historical and natural attractions
including Kartchner Caverns.
By appointment only: Tel/fax: (520) 615-3886
11331 East Placida Rancho Grande • Tucson, Arizona 85730-5808
http://www.communiverse.com/skywatcher
E-mail address: vegasky@earthlink.net

SUNSPOTTER®
THE SAFER SOLAR TELESCOPE

SUNSPOTTER

Learning Technologies, Inc.
40 Cameron Avenue • Somerville, MA 02144
Tel: 800-537-8703 • Fax: 617-628-8606
E-mail: sunspotter@starlab.com • www.starlab.com

SAME SUPERIOR QUALITY
NOW INCLUDES TWO PLOSSL EYEPIECES!

NEW
VALUE PRICE
$209⁰⁰

Astroscan®
2001 Wide-Field Telescope

The Heart Of The Astroscan is its 1/8 wave, overcoated primary parabolic mirror where "similar" telescopes use an inexpensive spherical mirror. The result is images that appear crisp and clear without any of the distorting effects of spherical mirror aberration.

An Ideal First Telescope For The Whole Family
The original Astroscan was the first and is still the best choice available for beginners looking for a low-cost, easy-to-use, maintenance-free telescope and for expert stargazers seeking a high-performance portable scope.

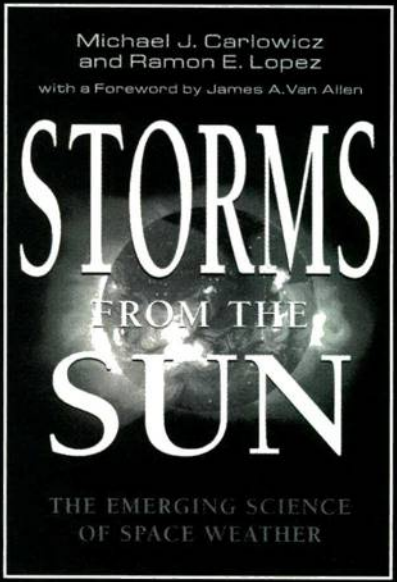
Basic Astroscan® Telescope Package
- Astroscan® Wide Field Telescope
- Cast Aluminum Padded Table-Top Base
- Instrument-Quality 28mm & 15mm Plössl Eyepiece
- Open Sight Target Finder
- Adjustable Shoulder Strap
- Star & Planet Locator
- 40 Page "Sky Guide" Book
- 36 Page User's Manual
- 5 Year ES Limited Warranty

Call 800-728-6999 for a FREE CATALOG
containing over 2000 scientific products for the entire family!

Dept. D021-C839 • 60 Pearce Ave., Tonawanda, NY 14150
Fax: 800-828-3299 • E-mail: cons_order@edsci.com
www.scientificsonline.com

Edmund Scientific's
SCIENTIFICS®

Forecasts call for SOLAR RUMBLES
followed by MASSIVE CORONAL EJECTIONS . . .



ISBN 0-309-07642-0 • HARDCOVER
248PP. • 6 X 9 • $27.95

"Ten years ago, almost no one had heard of 'space weather.' Now, few of us in the developed world can escape its influence. And no one writes about it with greater flair and clarity than Michael Carlowicz and Ramon Lopez."

—Stephen P. Maran, author,
Astronomy for Dummies® and editor,
The Astronomy and Space Science Encyclopedia

Co-published by the Joseph Henry Press and the Dana Press
www.jhpress.org

At fine bookstores near you

SCOPETRONIX
QUALITY ASTRONOMY PRODUCTS

PHONE/FAX
(239)945-6763

"The" place to look for new and unique accessories to get the most out of your scope!

ScopeTronix Digital Camera Solutions

We have the worlds largest selection of digital camera adapters

MaxView 40™ Eyepiece & Variable Projection Adapter for Digital Cameras

NEW PRODUCT!

The MaxView 40 is a unique fully multi-coated eyepiece and variable projection camera adapter all in one. For use as an eyepiece the eyeguard can be set to any height allowing for matching the eye relief to your eye for more comfortable viewing. In the left picture the threaded eyeguard has been removed revealing the integral "T" thread on the top of the eyepiece. The picture on the right shows how the outer sleeve can be adjusted up or down to the optimum setting to minimize vignetting for your particular camera. The MaxView 40™ is **specifically designed to help minimize vignetting in digital cameras with larger lenses** such as the Minolta D'image 5/7, Olympus 2xxx/3xxx/4xxx, Sony 505/707, Canon G1/G2 and many more. The MaxView 40™ is "T" threaded so you will need the proper step ring to mate it to your camera.

*Patent Pending

MaxView 40™ Eyepiece & Variable Projection Adapter..... **129.95**

Digi-T™ T-Ring adapter for 1.25" eyepieces

Digi-T mates most digital camera models to the following eyepieces (must have rubber eyeguards):
Meade ETX, MA, Series 4000 Super Plossls, NexStar Plossls, Sirius Plossls, ScopeTronix Plossls, Series 300/400, and many MORE!

Digi-T provides the closest possible connection for the fullest possible picture!
Digi-T is secure, quick, and easy to use. Now you can even use 40mm eyepieces!
Digi-T won't raise the eyepiece like a projection adapter, no back focus problems!
Digi-T kits are available to fit most common digital cameras, video cameras too!

Mounting is easy! Simply pull off the rubber eyeguard, slip the Digi-T over the top of the eyepiece and tighten the set screws into the groove. The Digi-T will be flush with the top of your eyepiece. Now just thread on the step ring that mates it to your camera!

*Patent Pending

We now stock over 50 kits to fit all popular Digital Cameras. Call or visit our website for details!

Wide Angle Eyepiece & Digital Camera Adapter for Nikon Cameras

These 1-1/4" Wide Angle eyepieces feature an AFOV of over 66 degrees! For use as a camera adapter simply unscrew the eyeguard to reveal a 28mm thread. This will thread directly into the Nikon 800/900/990/995. Adapters in stock for use with other Nikons and 37mm (many Sony) cameras.

STWA14 14mm... **109.00** | **STWA18** 18mm... **99.00**

ScopeTronix Zoom Eyepiece & Digital Camera Adapter for Nikon Cameras

Our quality 1-1/4" zoom eyepiece features a 7-21mm zoom range. Attach the 28mm digital camera adapter and it threads onto any camera with a 28mm lens thread!

STZ721 7-21mm zoom EP........................ **64.95**
STZ28 28mm digital camera adapter........ **34.95**

ScopeTronix EZ-PIX ™ Digital Camera Adapter

No lens thread on your digital camera? No problem! Our universal design fits any camera with a standard 1/4-20 threaded mounting hole. The padded eyepiece clamp slips over most Plössl eyepieces and barlow lens. The EZ-PIX is the original universal camera adapter, don't be fooled be cheap imitations that claim to be of an improved design. *The EZ-PIX is still the best design available!* Spacer included (shown at right)

Now includes two padded clamps to fit a wide variety of eyepieces!

EZPIX Universal Digital Camera Adapter.......... **49.95**

ScopeTronix Thread On Solar Filters for ETX Telescopes

Machined black aluminum filter cell securely threads onto ETX.
Quality Class A glass solar filter is manufactured by JMB.

SFETX60 fits ETX60 and ETX70.......... **64.95**
SFETX90 fits ETX 90........................... **84.95**
SFETX105 fits ETX 105......................... **94.95**
SFETX125 fits ETX 125......................... **99.95**

CrystalVue Optics Sharp Shooter 8x32mm Monocular and Digital Camera Lens

8x32mm monocular converts to a telephoto lens for digital cameras. Remove the rubber eyeguard to reveal a 37mm lens thread. Includes a 28mm to 37mm adapter ring.

CVOSS............. **149.00**

ScopeTronix ETX & NexStar Piggy Back Camera Mounts

PB70 ETX-60/70AT.... **42.95**
PBCM ETX-90EC/RA **49.95**
PB125 ETX-125EC... **64.95**
NPBACK NexStar 5 **59.95**
NPBACK8 NexStar 8 **35.00**

WE ACCEPT:
DISCOVER
VISA
MasterCard
AMERICAN EXPRESS Cards

NEW! Tripod Adapters & Accessory Holders for ETX!

See website for pricing

ScopeTronix ST Series Plössl Eyepieces

EP04 4mm ST Series Plössl **42.95**
EP06 6mm ST Series Plössl **42.95**
EP09 9mm ST Series Plössl **42.95**
EP15 15mm ST Series Plössl **42.95**
EP25 25mm ST Series Plössl **42.95**
EP30 30mm ST Series Plössl **52.95**
EP40 40mm ST Series Plössl **52.95**
EPSET Complete Set (7)....... **239.00**

ScopeTronix Flexi-Focus™ for ETX scopes

Oversized knob and flexible shaft allow crisp, sharp focusing even when OTA is pointed straight up!

FLEX70 For ETX-60/70AT.. **34.95**
FLEX90 For ETX-90EC/RA **34.95**
FLEX125 For ETX-125EC.. **34.95**

Flexible shaft reduces vibrations. Achieve sharp focus fast!

ScopeTronix Barlow Lenses

BAR2 2x.. **39.95**
BAR3 3x.. **42.95**

ScopeTronix Eyepiece Bottles & Filter Cases

We now stock 6 different size eyepiece bottles to fit almost any size eyepiece!

STSBOX Small 1-1/4" filter size box.......... **1.95**
STLBOX Large reducer/corrector size box **2.95**

ScopeTronix

Attention Beginners!
"Starry" says see
www.telescopes.org
for answers to your
questions!

Copyright 2002

TeleVue Visionary
MEADE

ScopeTronix Green Laser Pointer

5mw continuous mode laser beam is easily visible at night! 2 AAA batteries included. **$189**

ScopeTronix Astronomy Products • 1423 SE 10th Street Unit 1A • Cape Coral, Florida 33990

24 HOUR ONLINE SHOPPING & SECURE ORDERING
WWW.SCOPETRONIX.COM

KOWA Binocular Telescope
HIGH LANDER
PROMINAR

Dynamic Viewing

KOWA
HIGH LANDER
BINOCULAR
TELESCOPE
32X82

82mm Objective Lens

Prominar Model with Fluorite Crystal Lens

45° Offset Eyepiece for Long Term Viewing

Interchangable Eyepiece with 50x and 20x Optional Magnifications

For a Retailer Near You Call,
(800)-966-5692
www.kowa.com

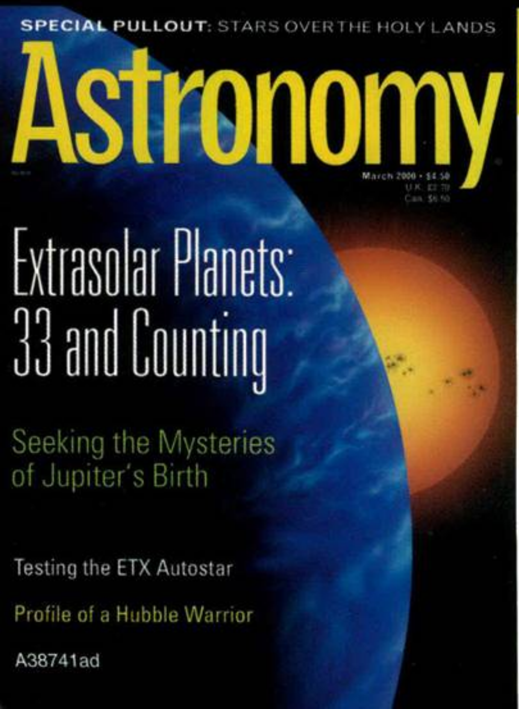
Kowa

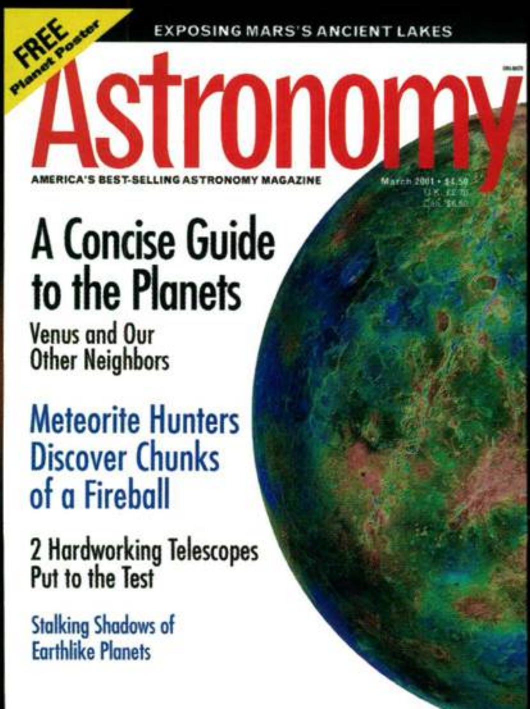
Kowa Company, Ltd.
Kowa Optimed, Inc.

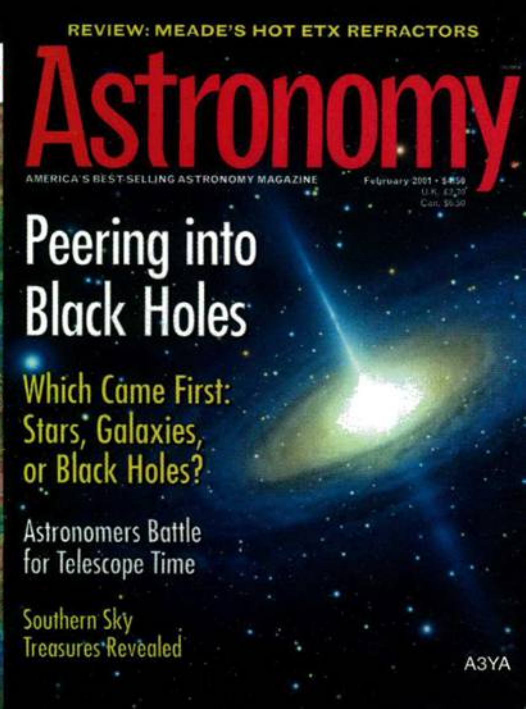
Read ASTRONOMY every month!

The world's most popular astronomy magazine! Each monthly issue includes up-to-date astronomy news, feature stories, and sky events. Plus, the latest product reviews, observing techniques for the amateur astronomer to the experienced star-gazer, dazzling, full-color photography, and more! Subscribe today!

Order online at astronomy.com or call 800-533-6644!


SPECIAL PULLOUT: STARS OVER THE HOLY LANDS
Astronomy
Extrasolar Planets: 33 and Counting
Seeking the Mysteries of Jupiter's Birth
Testing the ETX Autostar
Profile of a Hubble Warrior


EXPOSING MARS'S ANCIENT LAKES
FREE Planet Poster
Astronomy
AMERICA'S BEST-SELLING ASTRONOMY MAGAZINE
A Concise Guide to the Planets
Venus and Our Other Neighbors
Meteorite Hunters Discover Chunks of a Fireball
2 Hardworking Telescopes Put to the Test
Stalking Shadows of Earthlike Planets

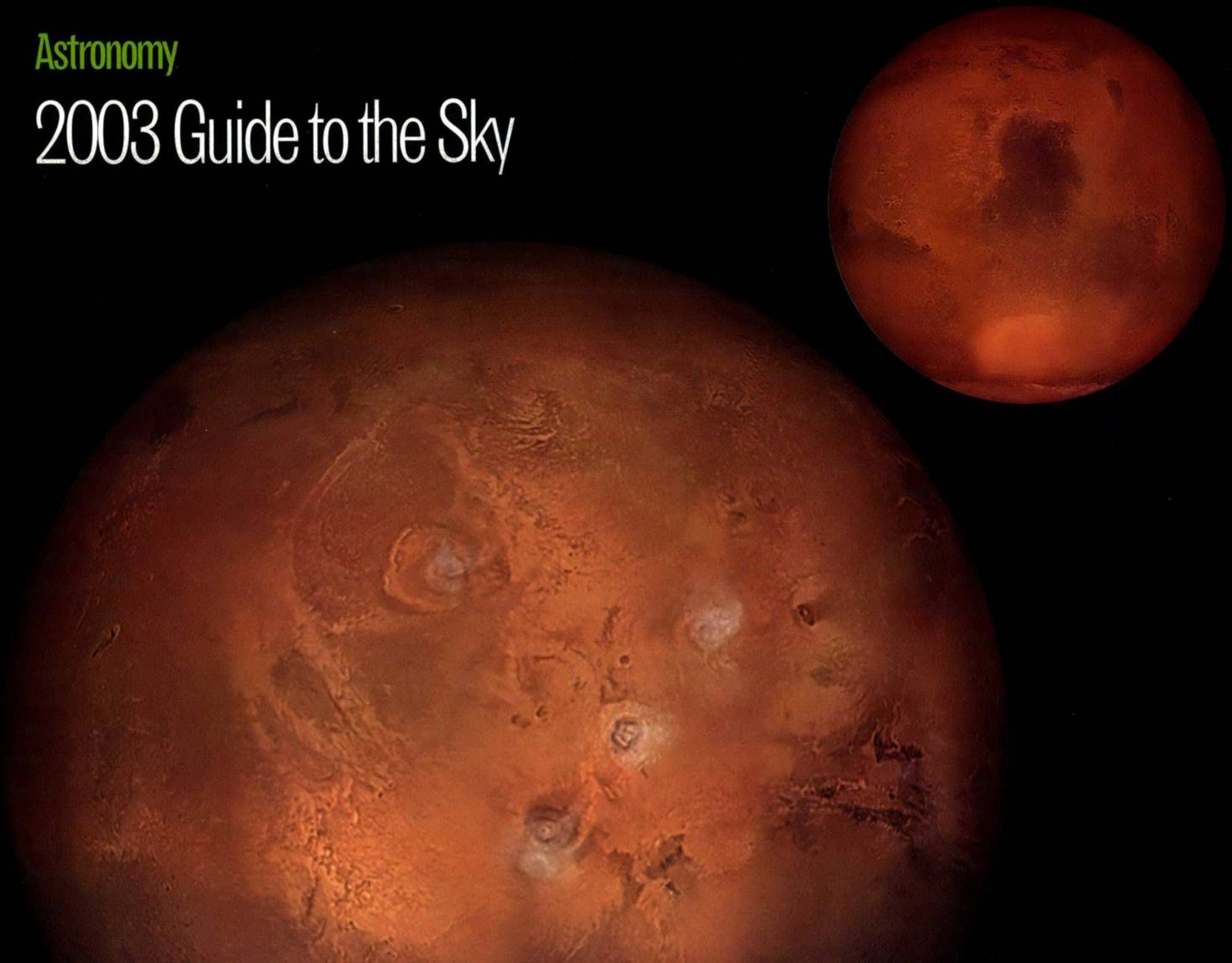

REVIEW: MEADE'S HOT ETX REFRACTORS
Astronomy
AMERICA'S BEST-SELLING ASTRONOMY MAGAZINE
Peering into Black Holes
Which Came First: Stars, Galaxies, or Black Holes?
Astronomers Battle for Telescope Time
Southern Sky Treasures Revealed

A38741ad

A3YA

Astronomy

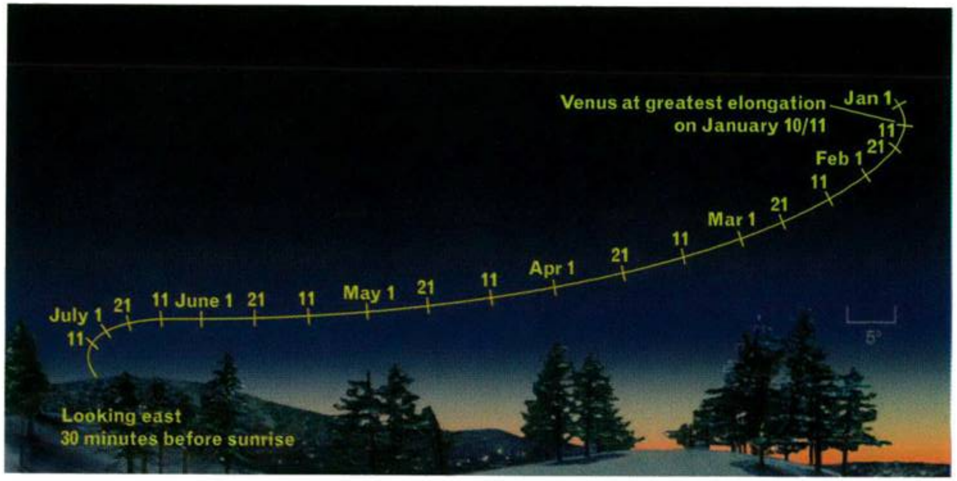
2003 Guide to the Sky



JAN

Venus Rules the Morning

Before dawn on January 1, Venus heralds the start of the new year. Rising more than three hours before the sun, its dazzling white glow outshines everything in the night sky except the moon. Any early risers will see its unmistakable appearance in the east, confusing some into thinking an aircraft has its landing lights on. Yet this brilliant light hangs in the east and does not land. The morning "star" shines at magnitude −4.5 on January 1.



Venus lies 47° west of the sun, its greatest elongation, on January 10/11. On that morning it stands high in the southeast before the light of dawn breaks the darkness of night. (To an observer on Venus, the sun and Earth would appear 90° apart in the sky.)

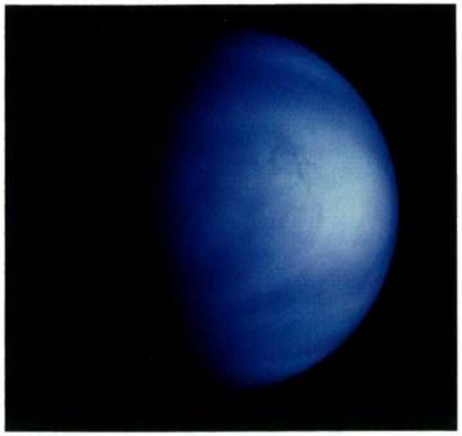
If we could view the solar system from above, we would see Venus moving away from Earth on a path that will eventually take it to the opposite side of the sun as seen from our home planet. As Venus follows this course, its telescopic appearance changes. The planet's phase grows from a fat crescent some 45 percent lit to a fully illuminated globe by August, when it reaches superior conjunction with the sun.

During the same period, the visible span of Venus's disk shrinks as the planet recedes from Earth. It starts the year with an angular diameter of 28", which shrinks to two-thirds that size by early February. Further changes take more time. The calendar will say June before the disk has shrunk to 10".

Throughout the first half of January, Venus moves through Libra, makes a brief foray into northern Scorpius, and then crosses into Ophiuchus on the 14th. A much dimmer planet, ruddy Mars, joins Venus throughout January. On the 1st, the 1.5-magnitude Mars stands 5° west of Venus. As the planets move along the ecliptic during January, the Red Planet ends the month just 5° north of Antares, the bright reddish star in Scorpius whose name means "rival of Mars."

The rich starfields of Sagittarius are home to Venus during February. Seeing such a brilliant object adjacent to the wonderful nebulae that dot this region is a treat. Venus lies 2° north of the Trifid Nebula (M20) on February 5 and 5° south of the Omega Nebula (M17) on the 8th. You'll need to catch the nebulae in a dark sky and at a reasonable altitude, so you'll be racing against the encroaching twilight. Try about an hour after Venus rises, just before twilight begins.

Venus heads into Capricornus during March and on the 12th passes a fraction of a degree north of Neptune, a difficult object at low altitude in the brightening twilight. By the end of March, Venus has moved very close to Uranus. In fact, they're so close that a telescope will show Venus with an apparent satellite. The low altitude and twilight conspire to produce a very narrow window for observers wanting to view this conjunction.


NASA/JPL

Following superior conjunction on August 18, Venus lies east of the sun and so can be seen only in the evening sky after the sun has set. Slowly but surely, Venus becomes the evening "star" by early October. It remains an evening object through the end of the year.

Saturn Crosses the Crab

Few Messier objects ever lie right in the path of a passing planet. Yet in early January, a rare transit of a planet across a famous feature takes place. On January 4 and 5, over a period of nearly 20 hours, Saturn passes right in front of the Crab Nebula (M1), the magnificent remnant of a supernova seen on Earth in 1054. Because Saturn is just past opposition, it remains visible all night from all parts of the globe. Consequently observers around the planet will have the opportunity to see at least part of this rare event, assuming the weather cooperates.

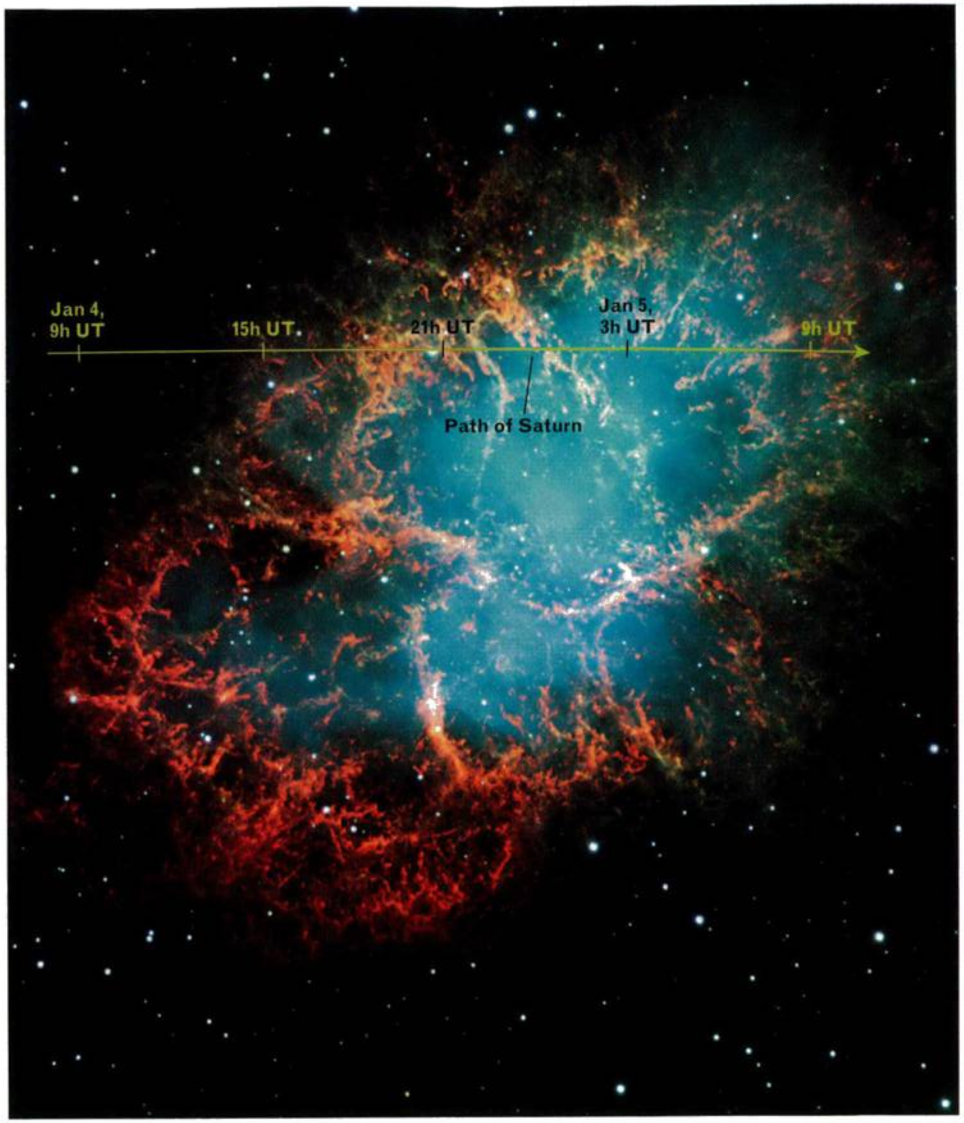
Saturn begins to transit M1 at approximately 15h Universal Time on January 4 (10 A.M. EST). It appears slightly north of the nebula's center around 2h UT on the 5th (9 P.M. EST on the 4th). This will be prime viewing for European observers and the start of a night of good views for the Americas. The brief transit ends at about 10h UT on January 5 (5 A.M. EST).

Observing the event visually should prove a fascinating challenge. The transit also represents a fine photographic opportunity, particularly for those with CCD cameras, which excel at capturing the wide range of brightness.

The usually starless Crab will feature additional bright points of light as Saturn's moons cross the faint nebula. Titan, the largest and brightest moon, follows the Ringed Planet across the nebula. Titan's transit begins at approximately 4h UT on January 5 (11 P.M. EST on the 4th) and ends some 24 hours later.

The Crab Nebula has a low surface brightness because it spans a fairly large area, some 6' by 4'. Saturn, shining at magnitude –0.4, will far outshine the 8th-magnitude nebula. Improve your chances of seeing both objects at once by viewing through as large a telescope as possible.

Saturn passes though solar conjunction on June 24 and returns to opposition in December, on the final night of 2003.



European Southern Observatory

S	M	T	W	T	F	S
			1	○	3	4
5	6	7	8	9	◑	11
12	13	14	15	16	17	●
19	20	21	22	23	24	◐
26	27	28	29	30	31	

EST

4 Quadrantid meteor shower peaks

10 **10 P.M.**
Venus is at greatest western elongation (47°, morning)

11 **3 P.M.**
Mercury is in inferior conjunction

15 **3 P.M.**
The moon passes 3° north of Saturn

19 **10 A.M.**
The moon passes 4° north of Jupiter

27 **10 A.M.**
The moon passes 0.4° south of Mars

28 **2 P.M.**
The moon passes 4° south of Venus

30 **7 P.M.**
Neptune is in conjunction with the sun

Events in **red** are ones you won't want to miss. All times in the calendar are eastern time. "Morning" or "evening" at the end of a listing denotes that the event appears before sunrise or after sunset, respectively.

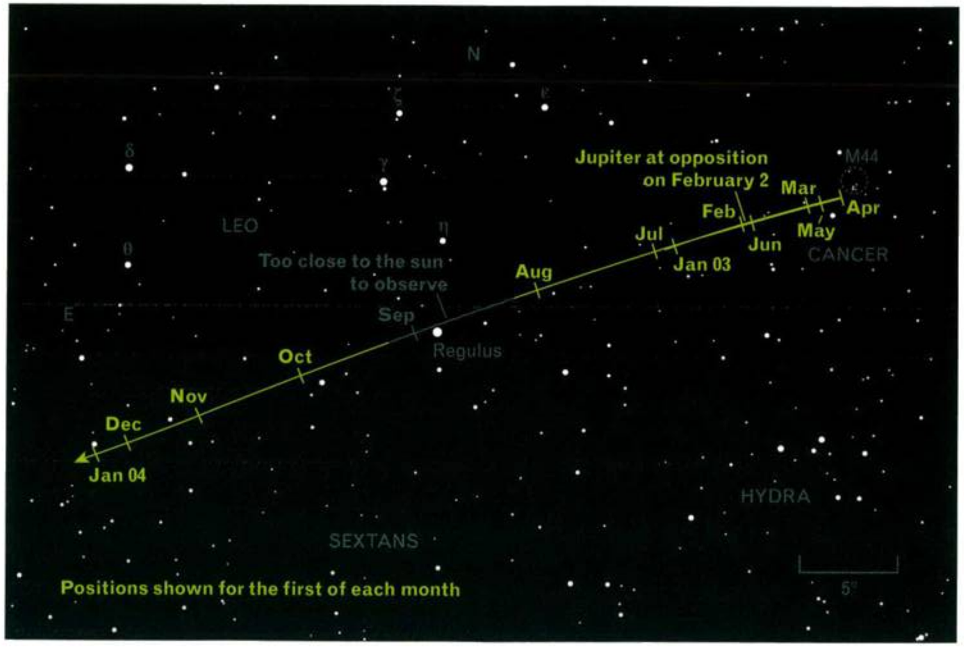
FEB

Long Live the King of Planets

Have you ever wondered how to recognize Jupiter in the sky? Because you're reading this, you're well on your way to finding out. You simply need a map of the sky. Finding planets is just like scanning a regular map showing where the locations of the major cities are in each state. Of course, there's a catch – the planets move and cities don't. However, once you identify the planet for the first time, it's pretty easy to keep track.

Jupiter stands high in the south around midnight during February. That's a direct consequence of its lying exactly opposite the sun as seen from Earth. This event, called opposition, occurs on February 2. The planet shines brightest and its disk appears largest through a telescope at opposition. This year Jupiter shines at magnitude –2.6 and spans 46" across its equator.

The backdrop of stars against which we view Jupiter this month belongs to the constellation Cancer the Crab. Watch Jupiter's motion from night to night. From February through April, Jupiter moves steadily closer to the Beehive star cluster (M44), located centrally in Cancer. The Beehive ranks among the finest open star clusters visible to the unaided eye or with binoculars. On April 4, Jupiter's westward motion relative to the stars slows to a halt, leaving the planet less than two moon-widths from the center of the Beehive cluster. Jupiter then shines at magnitude –2.3, a stunning contrast to the cluster of 6th-magnitude and fainter stars. Observing through binoculars on a moonless night will provide the best view. The cluster becomes harder to see when the moon lies nearby. Around the evenings of February 15, March 14, and April 10, the moon passes 4° north of Jupiter.



Positions shown for the first of each month

Jupiter's retrograde motion, which carries it in a westerly direction against the background stars, ends shortly after Earth overtakes Jupiter in our faster-paced orbit. Throughout late April and into May, the planet begins to move away from the Beehive as it resumes its normal easterly trek among the stars. As it does so, Jupiter shines brightly in the evening sky shortly after sunset. By early June, Jupiter stands low in the west at dusk, where it is visited by a slender crescent moon on June 4.

Jupiter slips behind the sun in August and reappears in the morning sky in late September among the stars of Leo. Jupiter typically spends each year-long apparition in one constellation along the ecliptic, because it takes about 12 years to orbit the

NASA/JPL/University of Arizona

sun and there are twelve major constellations along the ecliptic. This will help you keep track of Jupiter from year to year.

A recent count gives Jupiter a retinue of 39 moons, the largest number of any planet in the solar system. Most of them are tiny balls of ice and rock no more than a mile or two across, undoubtedly captured dead comets or small asteroids. Four of them range up to planet size, however, and glow brightly enough to be seen easily in small backyard scopes. These four — Io, Europa, Ganymede, and Callisto — were discovered by Galileo in 1610 when he trained his first telescope in Jupiter's direction. The moons change their relative positions from one night to the next as they orbit Jupiter. Tracking their nightly positions and comparing these to published predictions will help you identify each moon.

A Demon Stalks the Hero

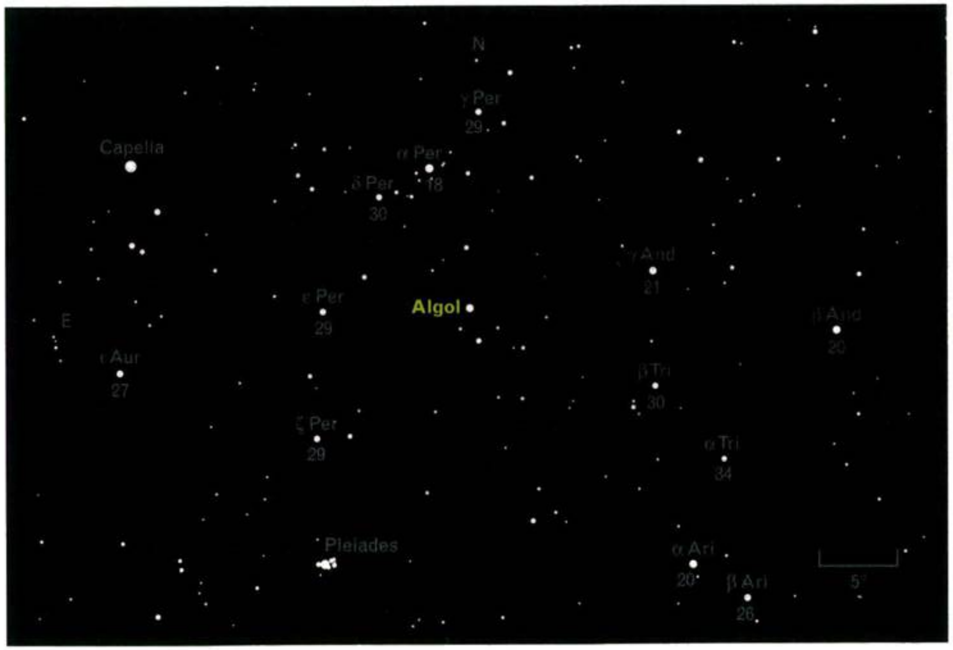
The ancients typically regarded change in the heavens as a portent of doom. Of course, the universe unfolds oblivious to the concerns of humans, many of whom are still trying to read meaning into it. Perhaps that's why the periodic variations of the star Algol originally led Arab astronomers to nickname it the Demon Star, although that name fits easily into Greek starlore as well. To the Greeks, Algol represented the head of Medusa, the serpent-haired woman whose eyes, if they were looked into, would turn the beholder to stone. The hero Perseus severed her hideous head and now carries it victoriously across the sky.

You can find Algol easily with your naked eye as it passes overhead during the early-evening hours in winter. Use Capella — the brightest star in this part of the sky — as your guide, then star-hop over to Perseus and Algol. It's a little harder to say how bright Algol will appear. Normally it shines at magnitude 2.1, rivaling the nearby stars Beta (β) and Gamma (γ) Andromedae to the west. Yet periodically it dims to magnitude 3.4 and appears as faint as Alpha (α) Trianguli.

Why does Algol vary in brightness? The star is what astronomers call an eclipsing binary, where two stars orbit each other in a tight gravitational embrace. We normally see the combined light from both stars, even though they lie so close together that they appear as one. But once each orbit, the cooler, fainter star passes in front of and partially hides the hotter, brighter one from view. The eclipses occur every 2 days 20 hours and 49 minutes and last for a little less than 10 hours.

February offers two excellent chances for observers across North America to see Algol in eclipse. The first comes on the night of February 9/10, when the star reaches its minimum brightness around 1:40 A.M. EST (10:40 P.M. PST). Remember to start watching earlier in the evening, however, because the eclipse starts nearly five hours before. The first quarter moon lies in nearby Taurus that night, but you should still be able to follow Algol as it fades by 1.3 magnitudes — a factor of more than three.

Three nights later, on February 12/13, Algol reaches its minimum at about 10:30 P.M. EST (7:30 P.M. PST). Observers that night have a good chance to watch Algol rise back to full intensity. Use the star map below to gauge Algol's brightness. The magnitudes of nearby comparison stars are shown without decimal points, to avoid confusion with faint stars.



S	M	T	W	T	F	S
						○
2	3	4	5	6	7	8
◑	10	11	12	13	14	15
●	17	18	19	20	21	22
◐	24	25	26	27	28	

EST

2 **4 A.M.**
Jupiter is at opposition

3 **8 P.M.**
Mercury is at greatest western elongation (25°, morning)

11 **10 P.M.**
The moon passes 3° north of Saturn

15 **1 P.M.**
The moon passes 4° north of Jupiter

17 **5 P.M.**
Uranus is in conjunction with the sun

20 **7 P.M.**
Mercury passes 1.6° south of Neptune (morning)

24 **midnight**
The moon passes 1.9° south of Mars

27 **6 A.M.**
The moon passes 5° south of Venus

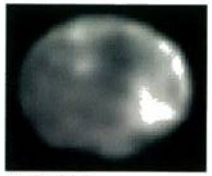
28 **10 A.M.**
The moon passes 5° south of Neptune

MAR

Glimpse Vesta with Your Naked Eye

Although the official count of solar system objects now reaches well over 10,000, the number of those visible with unaided vision remains at ten. And that includes both the sun and Earth – not exactly the first objects that come to mind when thinking about backyard observing. (This count does neglect the occasional bright comet, however.)

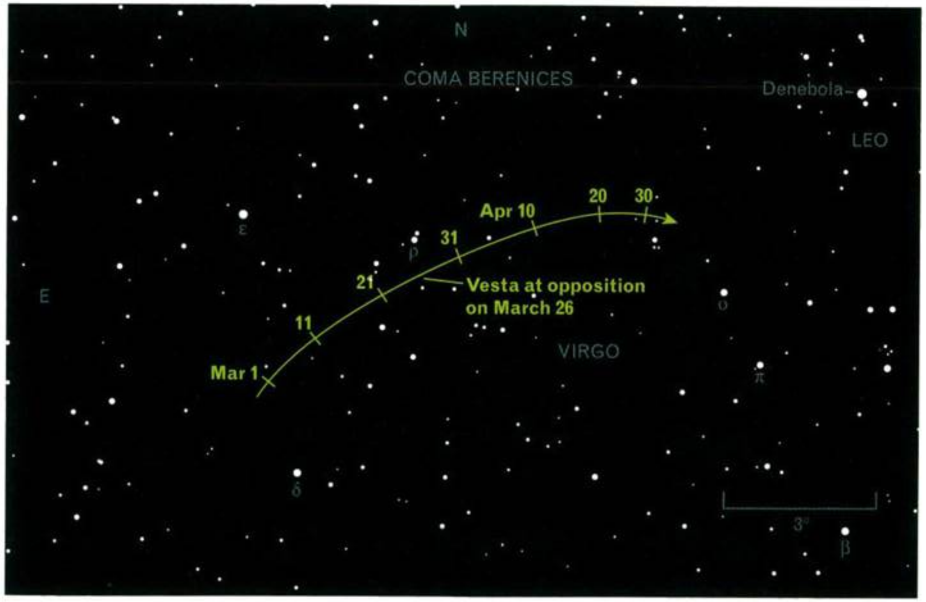
The bottom of this rarefied barrel is usually reserved for the asteroid 4 Vesta. This minor planet never glows brightly, but for a month or two at roughly 16-month intervals, it manages to reflect enough light in our direction to make a faint impression on unaided retinas. That time is now upon us. During March and April, Vesta glows at 6th magnitude and can be seen with the naked eye. The keys to finding it are an observing site with an inky-black sky and knowing exactly where to look.


NASA/STScI

As with any solar system object that orbits beyond Earth, the best time to view Vesta is when it lies opposite the sun in our sky. At opposition Vesta lies closest to Earth — and thus appears brightest — and remains above the horizon all night.

This year opposition comes on March 26 as Vesta glides among the background stars of Virgo. During the first week of March, you can find the asteroid about one-third of the way between the 3rd-magnitude stars Delta (δ) and Epsilon (ε) Virginis.

By the time opposition arrives in late March, Vesta has moved westward to a point just 1° south of 5th-magnitude Rho (ρ) Virginis. It then glows at magnitude 5.9 and should be fairly easy to find,



assuming you have clear and dark skies. Spotting it with your naked eye on the first attempt can be tricky, however. Use binoculars and the map above to zero in on the asteroid's location. Then set the binoculars aside and gaze upon Vesta.

It may come as a surprise to learn that Vesta was not the first asteroid discovered. That honor belongs to Ceres, initially spotted by Giuseppe Piazzi on the first day of the 19th century. The discovery of Vesta came six years (and three more asteroids) later, when Heinrich Olbers first detected it as a moving point of light. Vesta doesn't even rank as the largest asteroid. With a diameter of 335 miles (540 km), it ranks third, behind both Ceres and Pallas. Its claim to brightness stems from its orbit, which brings it closer to Earth than the other big asteroids, and a surface that reflects more sunlight

Exploring the Spring Sky

The Big Dipper, our signpost in the sky, swings high overhead during the spring and lies near the center of our star chart. This season of rejuvenation encourages us to move outdoors with the milder temperatures, and with it a grand group of stars beckons us.

Follow the arc of stars outlining the handle of the Dipper away from the bowl and you will land on brilliant Arcturus. This orangish star dominates the spring sky in the kite-shaped constellation Boötes. Well to the west of Boötes lies Leo the Lion. You can find its brightest star, Regulus, by using the pointer stars of the Dipper in reverse. Regulus lies at the base of a group of stars shaped like a backward question mark, which represents the head of the lion.

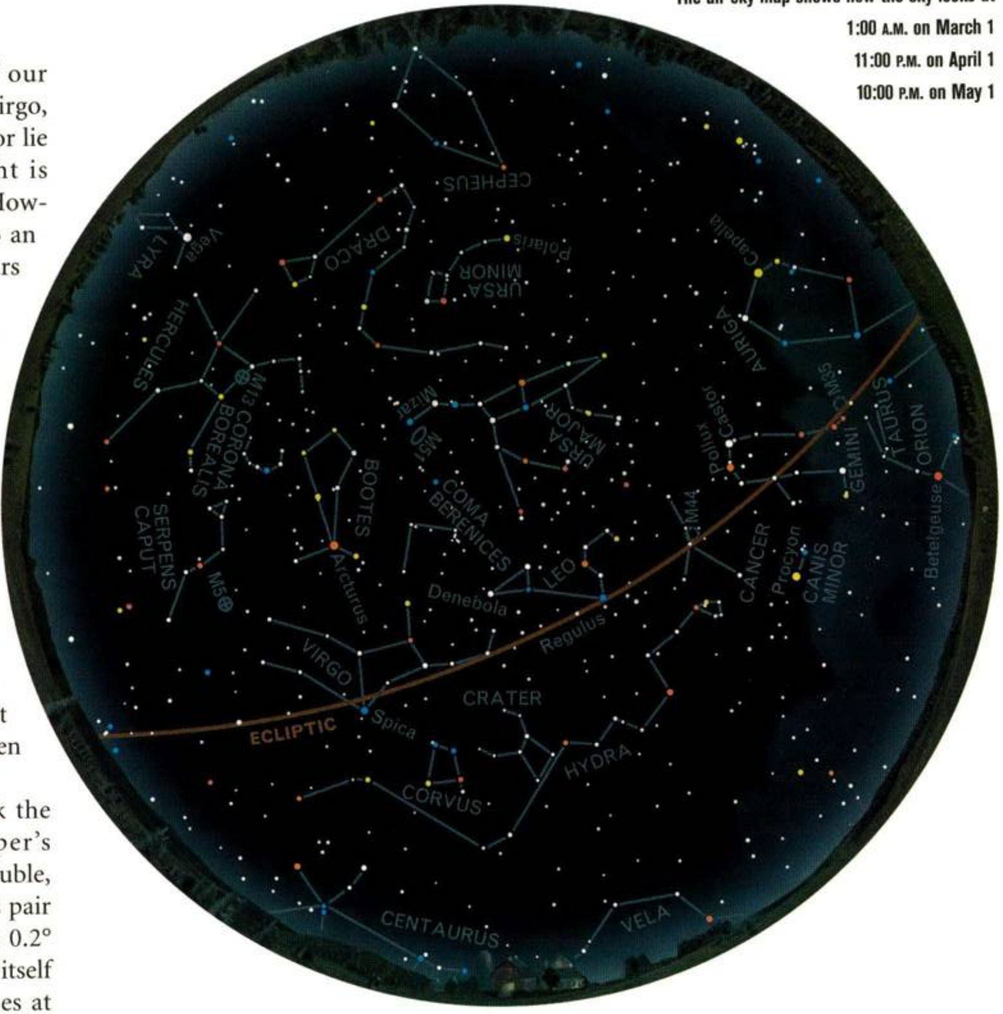
Midway between Regulus and Pollux in Gemini, which is now sinking in the west, is the diminutive group Cancer the Crab. Centered in the group is a hazy patch of light that binoculars reveal as the Beehive star cluster (M44).

To the southeast of Leo is the realm of the galaxies and the constellation Virgo the Maiden. Virgo's brightest star, Spica, shines at magnitude 1.0.

During springtime the Milky Way lies level with the horizon, and it's easy to realize that we are looking out of our galaxy's disk. In the direction of Virgo, Leo, Coma Berenices, and Ursa Major lie hundreds of galaxies whose light is unhindered by intervening dust. However, all these galaxies are elusive to an untrained eye and require binoculars or a telescope to be seen.

Boötes lies on the eastern border of this galaxy haven. Midway between Arcturus and Vega, the bright "summer" star rising in the northeast, is a region where no star shines brighter than 2nd magnitude. A semicircle of stars represents Corona Borealis, and adjacent to it is a large region that houses Hercules, the fifth-biggest constellation. It's here we can find the northern sky's brightest globular cluster, M13. A naked-eye object from a dark site, it is spectacular when viewed through a telescope.

Returning to Ursa Major, check the second-to-last star in the Dipper's handle. Most people will see it is double, while binoculars show it easily. This pair is called Mizar and Alcor. They lie 0.2° apart, and a telescope shows Mizar itself is also double. Its companion shines at magnitude 4.0 and is 14" from Mizar.


CEPHEUS
Polaris
URSA MINOR
DRACO
Vega
LYRA
HERCULES
M13
CORONA BOREALIS
SERPENS CAPUT
M5
Mizar
M51
URSA MAJOR
BOOTES
Arcturus
COMA BERENICES
Denebola
LEO
Regulus
VIRGO
Spica
ECLIPTIC
CRATER
CORVUS
HYDRA
CENTAURUS
VELA
M44
CANCER
Procyon
CANIS MINOR
Pollux
Castor
AURIGA
Capella
GEMINI
M35
TAURUS
ORION
Betelgeuse

The all-sky map shows how the sky looks at
1:00 A.M. on March 1
11:00 P.M. on April 1
10:00 P.M. on May 1

S	M	T	W	T	F	S
						1
○	3	4	5	6	7	8
9	10	◐	12	13	14	15
16	17	●	19	20	21	22
23	◐	25	26	27	28	29
30	31					

EST

11 **7 A.M.**
The moon passes 3° north of Saturn

12 **3 P.M.**
Venus passes 0.2° north of Neptune (morning)

14 **7 P.M.**
The moon passes 4° north of Jupiter

20 **8 P.M.**
Equinox (northern spring/southern autumn begins)

21 **7 P.M.**
Mercury is in superior conjunction

25 **1 P.M.**
The moon passes 3° south of Mars

26 **6 P.M.**
Asteroid Vesta is at opposition

27 **5 P.M.**
The moon passes 5° south of Neptune

28 **8 A.M.**
Venus passes 0.05° north of Uranus (morning)

29 **3 A.M.**
The moon passes 5° south of Uranus
5 A.M.
The moon passes 5° south of Venus

APR

Mercury's Best Show of the Year

Flitting around the sun like a perpetual firefly, Mercury always lingers near the bright glow of our home star. It remains on a tight gravitational leash, averaging just 36 million miles from the sun. During its 88-day-long orbit, Mercury flips alternately to the east and west of the sun as seen from Earth. The effects of this motion result in the planet's brief visibility, alternating between the evening sky and morning sky.

For Northern Hemisphere observers this year, the best evening views occur in April and the most favorable morning views come in late September and early October. As with any planet located near the sun in the sky, the quality of a Mercury apparition depends on the state of the ecliptic — the apparent path of the sun across the sky that the planets also follow closely. In early spring at mid-northern latitudes, the ecliptic makes a steep angle to the western horizon after sunset, so Mercury's angular distance from the sun translates into altitude above the horizon.

During an evening apparition, Mercury follows a path that takes it from the far side of the sun to a point between the sun and Earth. Consequently its phase changes from full to a thin crescent, similar to the phases we see with the moon.

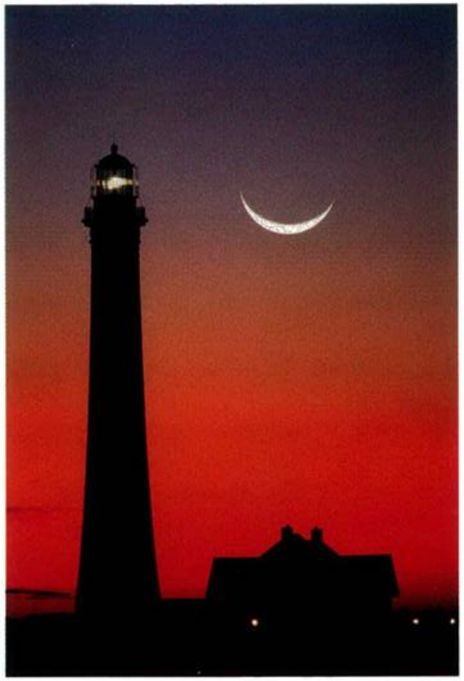
A simultaneous increase in the angular diameter of Mercury accompanies the change in phase. Why is this useful to know? Because these changes directly affect the brightness of Mercury. Mercury shines brightest during its gibbous phase and dims as it wanes to a crescent. Even though Mercury approaches Earth as the current apparition proceeds, easing the drop in brightness slightly, the planet's phase plays a greater role. On April 1, Mercury shines at magnitude −1.4 (as bright as Sirius) and sets nearly an hour after the sun. Look carefully for the young crescent moon alongside Mercury on the 2nd. By April 16 the planet has faded to magnitude 0.1, and it reaches magnitude 1.0 less than a week after that.

Even as its brightness drops, Mercury begins to appear in a darker sky as its elongation east of the sun increases. The innermost planet reaches its greatest angular separation of 20° on April 16. Although this is relatively small as far as Mercury elongations go, the steep angle of the ecliptic saves the day, placing the planet 13° above the western horizon 30 minutes after sunset. It then sets nearly two hours after the sun. Contrast this to the greatest elongation of August 14. Mercury then lies 27° east of the sun yet appears only 5° high in the west a half hour after the sun goes down and sets within another 30 minutes. (The table below shows the peak altitude for an observer at 40° north latitude either 30 minutes after sunset or before sunrise.)

Following this evening apparition, Mercury passes directly between the sun and Earth. This results in a transit of Mercury's disk across the face of the sun

NASA/JPL

on May 7, although the event occurs at night for observers in the western two-thirds of North America (see May).



Larry Landolfi

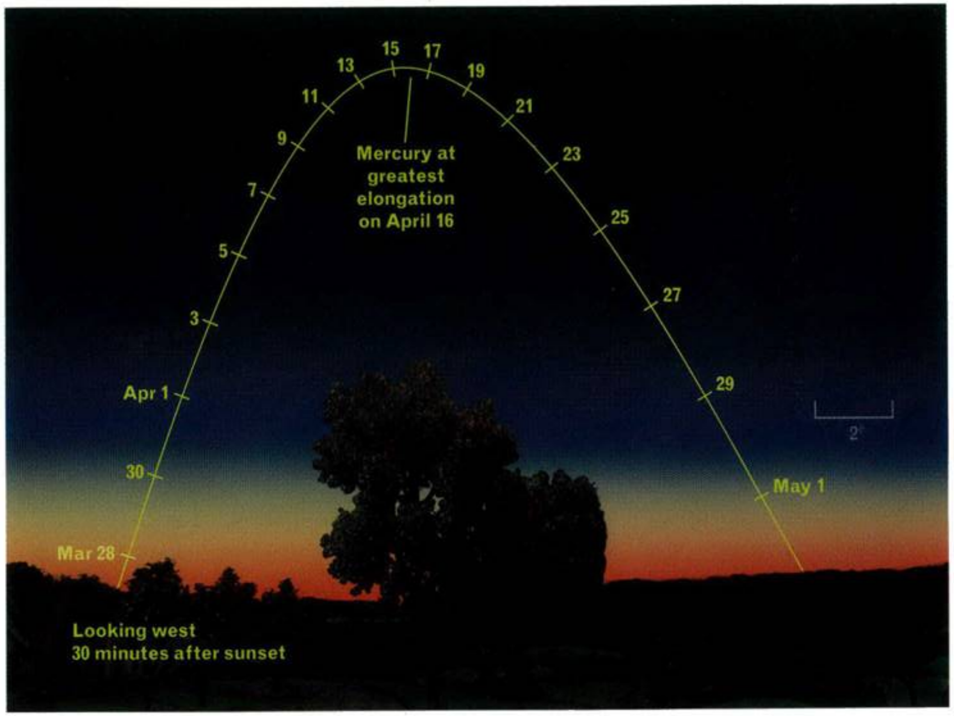
Catch a Young Moon's Glow

Detecting the slender crescent of the moon right after new moon is a challenge that appeals to many observers. Sometimes conditions prove ideal for catching the young crescent only 18 to 20 hours after new moon. Such views are rare, but even spying the moon within the first 30 hours after its new phase represents a big enough challenge for most of us. To our advantage, during springtime the ecliptic rises steeply from the western horizon after sunset, placing the young moon as high as possible in the early evening sky. Confounding our efforts, local conditions such as weather and obscured views to the west combine to make seeing the young moon a formidable task.

April 2 offers perhaps the best chance this year to spot a young moon about 30 hours old. The moon reaches its new phase at 2:19 P.M. EST on April 1. The following evening, the moon will be approximately 28 hours old as the sun sets for observers along the east coast of the United States. The moon sets about one hour after the sun, so east coast viewers have an opportunity to see the crescent when it is less than 29 hours old.

The moon grows progressively older the farther west you live — approximately one hour older for each time zone. So, on the west coast, the moon will be a little less than 32 hours old on the evening of the 2nd. You'll need a sky free of any clouds or haze and an observing site that gives a clear, unobstructed view right down to the western horizon. The time of sunset varies depending on your location, so check a local newspaper for the exact time. Careful planning will increase your chances of seeing the young moon.

The planet Mercury provides a helpful guide to finding the crescent moon on the evening of the 2nd. The planet shines at magnitude –1.3 that evening and lies less than 4° to the moon's right. Both objects will be visible within the field of view of 7x50 binoculars.



WHEN TO SEE MERCURY IN 2003

Evening			Morning		
Greatest elongation	Visible from	Peak altitude	Greatest elongation	Visible from	Peak altitude
April 16	Mar. 31 to Apr. 28	13°	February 3	Jan. 18 to Mar. 12	9°
August 14	July 13 to Sep. 4	5°	June 3	May 16 to June 28	5°
December 9	Nov. 10 to Dec. 21	7°	September 26	Sep. 18 to Oct. 13	11°

S	M	T	W	T	F	S
		○	2	3	4	5
6	7	8	◑	10	11	12
13	14	15	●	17	18	19
20	21	22	◐	24	25	26
27	28	29	30			

EDT

7 **6 P.M.**
The moon passes 3° north of Saturn

11 **4 A.M.**
The moon passes 4° north of Jupiter

16 **11 A.M.**
Mercury is at greatest eastern elongation (20°, evening)

22 Lyrid meteor shower peaks

23 **3 A.M.**
The moon passes 3° south of Mars
midnight
The moon passes 5° south of Neptune

25 **noon**
The moon passes 5° south of Uranus

28 **1 P.M.**
The moon passes 3° south of Venus

MAY

The Moon's Disappearing Act

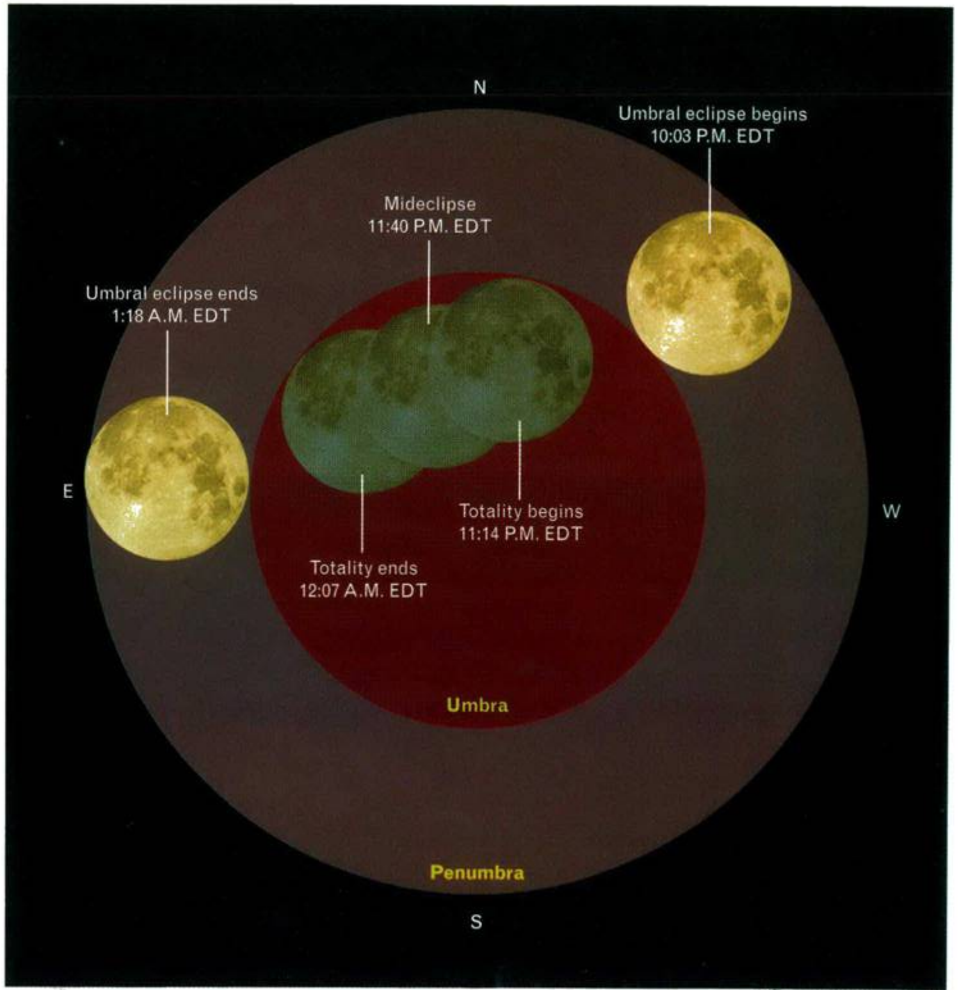
On the night of May 15/16, people across the Americas will have front-row seats to their first total lunar eclipse in over three years. For more than 50 minutes, the moon will slip completely into the darkest part of Earth's shadow, and the only light hitting the moon will be the reddish glow from all of Earth's sunrises and sunsets.

Few sky events can match a total lunar eclipse. Watching the full moon transformed into a reddish globe is a sight not soon forgotten. And you can enjoy an eclipse with any equipment you have – totality looks grand to the naked eye, in binoculars, or through a telescope.

Pedro Ré

The action starts when the moon first touches the lighter, outer part of Earth's shadow, the penumbra, at 9:05 P.M. EDT on the 15th. The penumbra imparts only a subtle darkening to the moon's surface, however, that most casual observers miss.

The main event gets underway when the moon enters the darkest part of our planet's shadow, the umbra, at 10:03 P.M. EDT. Within minutes, observers will begin to notice a small bite taken out of the moon's western limb. This stage will be seen throughout the eastern two-thirds of


N
Umbral eclipse begins
10:03 P.M. EDT
Mideclipse
11:40 P.M. EDT
Umbral eclipse ends
1:18 A.M. EDT
E
W
Totality begins
11:14 P.M. EDT
Totality ends
12:07 A.M. EDT
Umbra
Penumbra
S

North America and all of South America, as well as much of Europe and Africa (where it is before dawn on the 16th). For the next 70 minutes, the moon edges ever deeper into the shadow.

The shadow at first appears black in contrast to the rest of the moon, which remains bathed in sunshine. As the partial phases progress, however, and more of the lunar surface slips into the shadow, the moon starts to take on a dull orange to reddish hue. Totality arrives at 11:14 P.M. EDT (8:14 P.M. PDT) and lasts until 12:07 A.M. EDT (9:07 P.M. PDT), by which time the moon has risen across all of the Americas. The partial phases then play out in reverse. The moon leaves the umbral shadow at 1:18 A.M. EDT (10:18 P.M. PDT), concluding the three-hour show.

Targeting the Sun

Astrologers may talk about planets being aligned, but skywatchers will be waxing poetic about the grand alignments coming in May. In addition to the lunar eclipse of May 15/16, both Mercury and the moon will pass directly between the sun and Earth.

Mercury takes the plunge first, sliding in front of our star on May 7 in an event known as a transit. Mercury appears as a tiny black dot that moves slowly across the northern hemisphere of the sun. The entire transit will last 5 hours and 19 minutes.

NASA/TRACE

If Mercury's orbit coincided with the ecliptic plane, there would be a transit at every inferior conjunction, which occur three or four times every year. But its orbit tips 7° to the ecliptic, so Mercury usually passes north or south of the sun as seen from Earth. The planet crosses the ecliptic twice each year, around May 8 and November 10. Consequently, transits of Mercury occur only when the planet reaches inferior conjunction near those dates. That happens, on average, 13 times a century.

All of this year's transit can be seen from most of Europe, Africa, and Asia. Japan, Australia, and New Zealand will see the beginning of the transit before the sun sets. And observers in eastern North and South America can witness the end of the transit after the sun rises. Mercury starts to cross the sun's face at 5h13m Universal Time and finishes at 10h32m UT. In eastern North America, that means the transit can be seen low in the eastern sky from sunrise until 6:32 A.M. EDT.

To view the tiny disk of Mercury, which spans just 12" of the sun's 32' diameter, you'll want a telescope operating at a magnification of 50x to 100x. As with any solar viewing, make sure to have a high-quality solar filter over the front end of your telescope.

The same precautions apply to May's final alignment. On the 31st, Earth's moon passes directly in front of the sun. Unfortunately, the moon lies far enough from Earth that it can't completely cover the sun — even at the eclipse's peak, observers will see a ring of sunlight around the moon.

This annular solar eclipse boasts a track of annularity that stretches nearly 750 miles (1,200 kilometers) across — the widest for any central eclipse of the 21st century. But the annular phase can be seen only at high northern latitudes, where the wide swath doesn't translate into a lot of people living along the track. Only observers in northern Scotland, the island of Iceland, and the central third of Greenland will see this annular eclipse.

Phil Lohmann

S	M	T	W	T	F	S
				○	2	3
4	5	6	7	8	◑	10
11	12	13	14	●	16	17
18	19	20	21	◐	23	24
25	26	27	28	29	30	○

EDT

3 **7 A.M.**
Asteroid Juno is at opposition

5 **5 A.M.**
The moon passes 3° north of Saturn
Eta Aquarid meteor shower peaks

7 **3 A.M.**
Mercury is in inferior conjunction; transit

8 **2 P.M.**
The moon passes 4° north of Jupiter

13 **10 A.M.**
Mars passes 2° south of Neptune (morning)

15 **midnight**
Total lunar eclipse

21 **4 P.M.**
The moon passes 3° south of Mars

27 **8 P.M.**
Mercury passes 2° south of Venus (morning)

28 **10 P.M.**
The moon passes 2° north of Mercury
midnight
The moon passes 0.1° north of Venus

30 **midnight**
Annular solar eclipse

JUN

Hunt Down the Last Planet

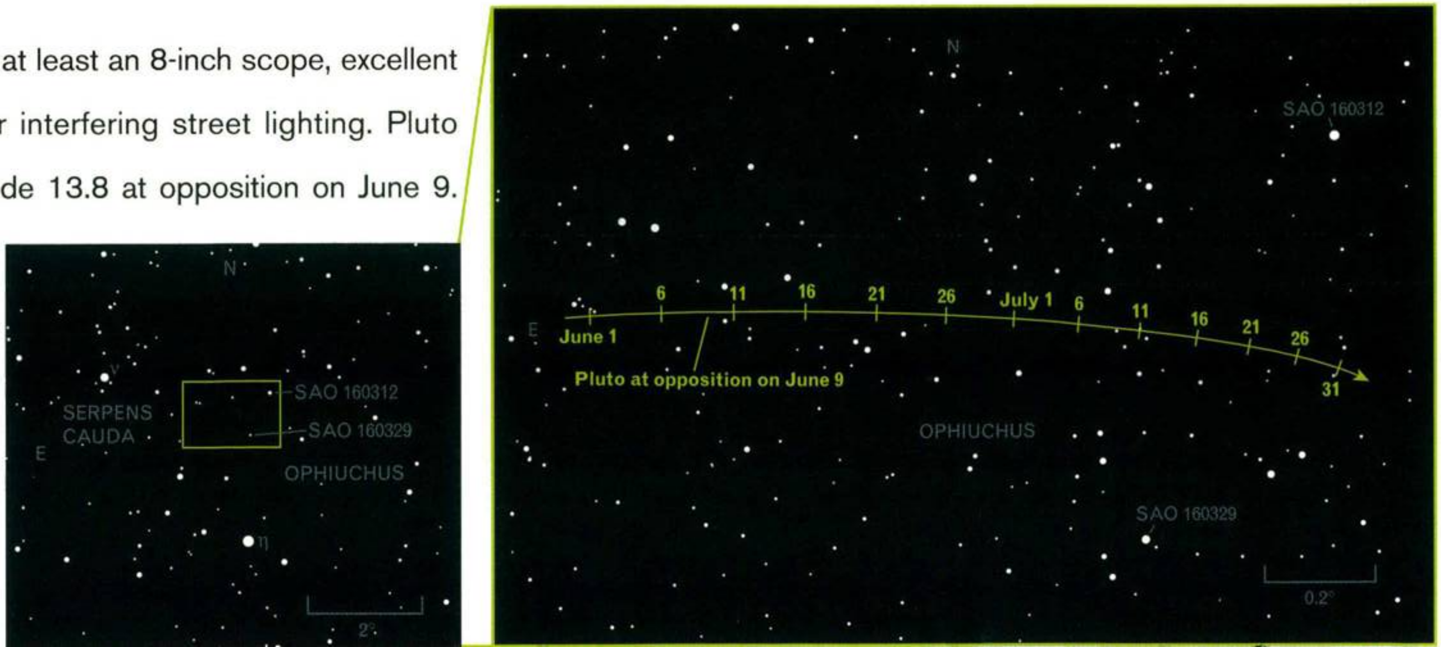
When Pluto lies near a bright star, especially a well-known one, the star acts as a fine signpost to finding the solar system's faintest planet. Pluto reaches opposition this month just slightly north of Sabik, the 2.4-magnitude star also known as Eta (η) Ophiuchi. Sabik is the southernmost star in the main figure of the large constellation Ophiuchus the Serpent-Bearer.

To begin your search, you'll need at least an 8-inch scope, excellent sky transparency, and no moon or interfering street lighting. Pluto glows dimly, reaching only magnitude 13.8 at opposition on June 9.

On that date it lies at its highest altitude in the south at local midnight. In regions where daylight-savings time is in effect, local midnight occurs closer to 1 A.M.

Find Sabik in a low-power eyepiece and then move 2.6° due north to find the 8th-magnitude star SAO 160312. During early June, Pluto lies east and a little south of this star. (On June 5 Pluto appears about a half degree south of the planetary nebula NGC 6309, also known as the Box Nebula. This 12th-magnitude planetary should be visible on any night good enough to also see Pluto.) Throughout June and July, Pluto drifts slowly west, ending July 0.3° south of SAO 160312. Use the star chart below to find the correct field and then center Pluto's location before moving to a higher magnification.

Once you have found the right field of view, the main challenge comes in identifying the elusive planet. By comparing what you see in the field with the star map below (which shows stars down to magnitude 14.5), you should be able to tell which faint dot of light marks Pluto. If not, carefully record the position of all the faint stars in your eyepiece's field of view. Then plan a second night of observing a day or two later. On the second night, record the same field. Pluto's identity should reveal itself by its motion relative to the "fixed" stars.



Exploring the Summer Sky

The richness of the summer sky is exemplified by the splendor of the Milky Way. Stretching from the northern horizon in Perseus, through the cross-shaped constellation of Cygnus overhead, and down to Sagittarius in the south, the Milky Way is packed with riches. These riches include star clusters, nebulae, double stars, and variable stars.

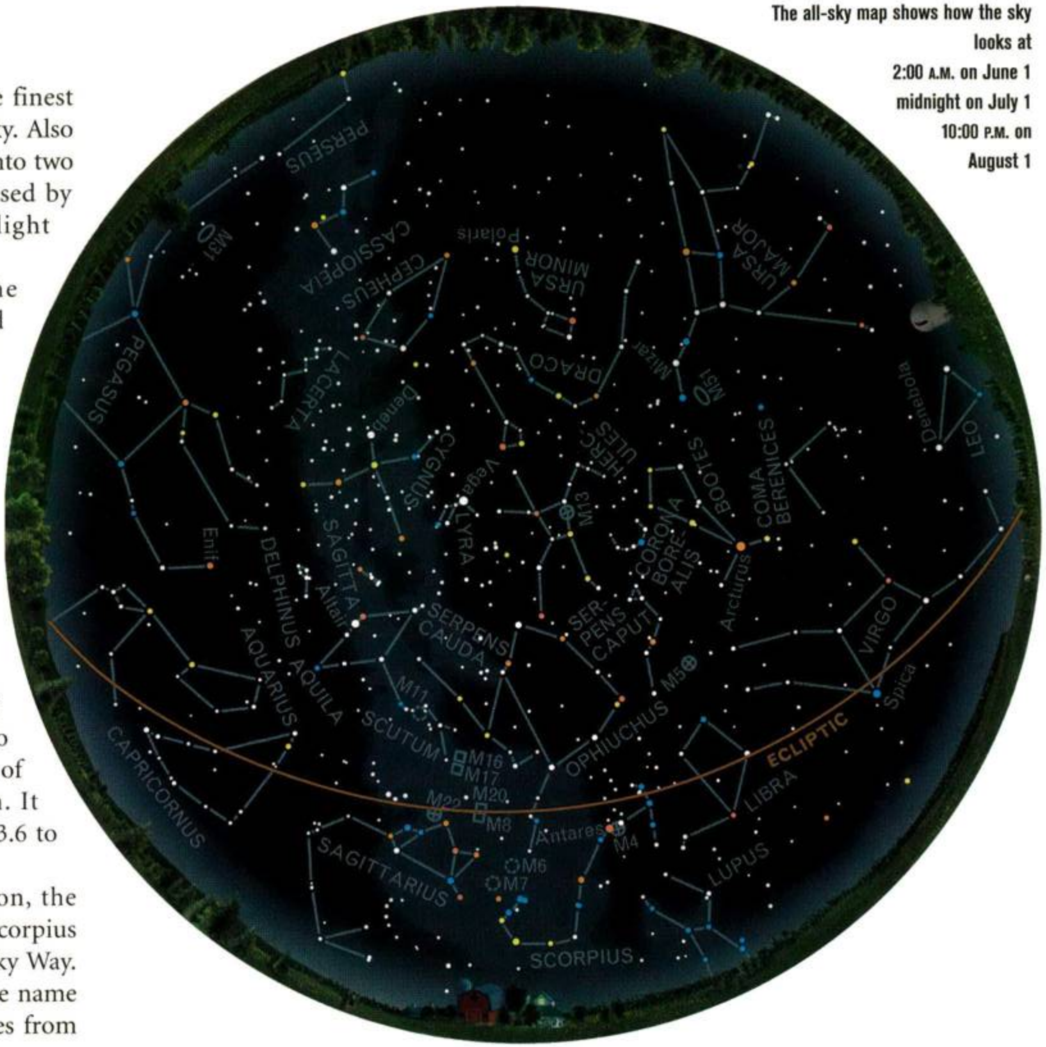
Let's start with the Big Dipper, our stellar signpost, which now lies in the northwest with its handle still pointing toward Arcturus. High overhead, and the first star to appear after sunset, is Vega in Lyra the Harp. Vega forms one corner of the summer triangle, a familiar asterism of three stars. Near Vega is the famous double-double star, Epsilon (ε) Lyrae. Two 5th-magnitude stars lie just over 3' apart, and can be split in binoculars. Each of these two stars is also double, but you need a telescope to split them.

To the east of Vega lies the triangle's second star: Deneb in Cygnus the Swan (some see a cross in this pattern). Deneb marks the tail of this graceful bird, the cross represents its outstretched wings, and the base of the cross denotes its head, which is marked by the incomparable double star, Albireo — a match of a 3rd-magnitude yellow star and a 5th-magnitude blue star offering the finest color contrast anywhere in the sky. Also notice that the Milky Way splits into two parts in Cygnus, a giant rift caused by interstellar dust blocking starlight from beyond.

Altair, the third star of the summer triangle, is the second brightest of the three. Lying 17 light-years away, it's the brightest star in Aquila the Eagle.

Frequently overlooked to the north of Deneb lies the constellation Cepheus the King. Shaped somewhat like a bishop's hat, the southern corner of Cepheus is marked by a compact triangle of stars that includes Delta (δ) Cephei. This famous star is the prototype of the Cepheid variable stars used to determine the distances to some of the nearer galaxies to our own. It varies regularly from magnitude 3.6 to 4.3 in 5.37 days.

Hugging the southern horizon, the constellations of Sagittarius and Scorpius lie in the thickest part of the Milky Way. Antares is a supergiant star whose name means "rival of Mars" and derives from its similar color and brightness.


PERSEUS
M31
CASSIOPEIA
CEPHEUS
Polaris
URSA MINOR
URSA MAJOR
PEGASUS
LACERTA
Deneb
DRACO
Mizar
M51
LEO
Denebola
CYGNUS
Vega
LYRA
M13
HERCULES
BOOTES
COMA BERENICES
CORONA BOREALIS
Arcturus
Enif
DELPHINUS
SAGITTA
Altair
SERPENS CAUDA
SERPENS CAPUT
M5
VIRGO
Spica
AQUARIUS
AQUILA
M11
SCUTUM
M16
M17
M20
M22
M8
OPHIUCHUS
ECLIPTIC
LIBRA
CAPRICORNUS
SAGITTARIUS
M6
M7
Antares
M4
LUPUS
SCORPIUS

The all-sky map shows how the sky looks at
2:00 A.M. on June 1
midnight on July 1
10:00 P.M. on August 1

S	M	T	W	T	F	S
1	2	3	4	5	6	◑
8	9	10	11	12	13	●
15	16	17	18	19	20	◐
22	23	24	25	26	27	28
○	30					

EDT

1 **5 P.M.**
The moon passes 4° north of Saturn

3 **2 A.M.**
Mercury is at greatest western elongation (24°, morning)

5 **2 A.M.**
The moon passes 4° north of Jupiter

9 **5 P.M.**
Pluto is at opposition

17 **5 P.M.**
The moon passes 5° south of Neptune

18 **3 P.M.**
Venus passes 5° north of Aldebaran (morning)

19 **2 A.M.**
The moon passes 1.7° south of Mars
4 A.M.
The moon passes 5° south of Uranus

20 **7 P.M.**
Mars passes 3° south of Uranus (morning)

21 **3 P.M.**
Solstice (northern summer/southern winter begins)

24 **10 A.M.**
Saturn is in conjunction with the sun

JUL

A Dazzling Evening Duo

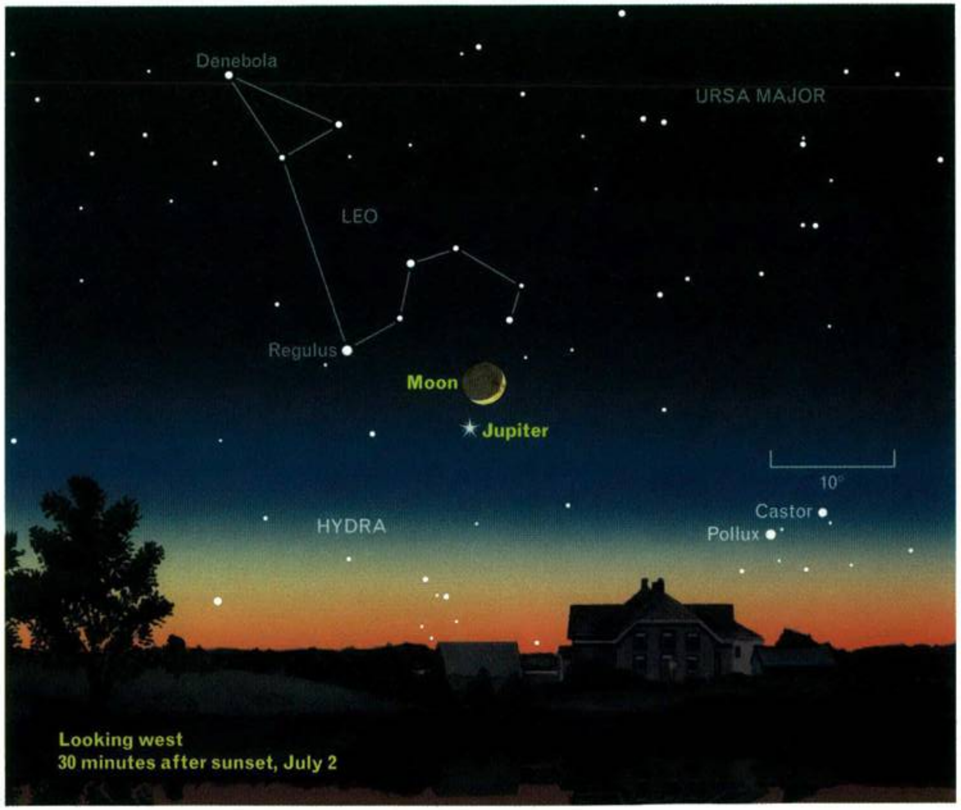
Throughout the year, the moon continually passes close to bright planets. The best of these conjunctions occur when the planet lies low in the west and a slender crescent moon sits nearby. Although conjunctions have no significance aside from highlighting our ability to accurately predict when they occur, the sheer beauty of such events creates the main attraction.

This July, Jupiter fits the bill perfectly. During the early evening hours of July 2, Jupiter and a waxing crescent moon hang delicately in the western sky an hour after the sun sets.

Jupiter lies just within the borders of Leo the Lion and shines at a dazzling magnitude of –1.8. The 3-day-old moon hangs 3° above Jupiter. Backed by the changing hues characteristic of a summer sunset, the attractive scene can be captured on film. Regulus, the brightest star in Leo, lies 11° farther east than Jupiter.

Binoculars show the scene best. Both Jupiter and the moon appear in the same field of view, and the "dark side" of the moon glows softly because of reflected earthlight. If you were standing on the moon looking at Earth, our home planet would appear almost full. Earth shines so brightly that it illuminates the moon far more than a full moon does on Earth. This "earthshine" causes the moon's dark side to be faintly visible whenever the moon appears as a thin crescent.

The previous night, on July 1, the slim crescent hangs near the Beehive cluster in Cancer, though the cluster glows too dimly to be seen in twilight. On July 3, a fatter crescent lies in central Leo. Following last year's deluge of wonderful conjunctions.



Looking west
30 minutes after sunset, July 2

Gianni Tumino

2003 seems rather sparse. The Jupiter-moon conjunction in early July ranks as the best of the year, so make the most of it.

Feel the Scorpion's Sting

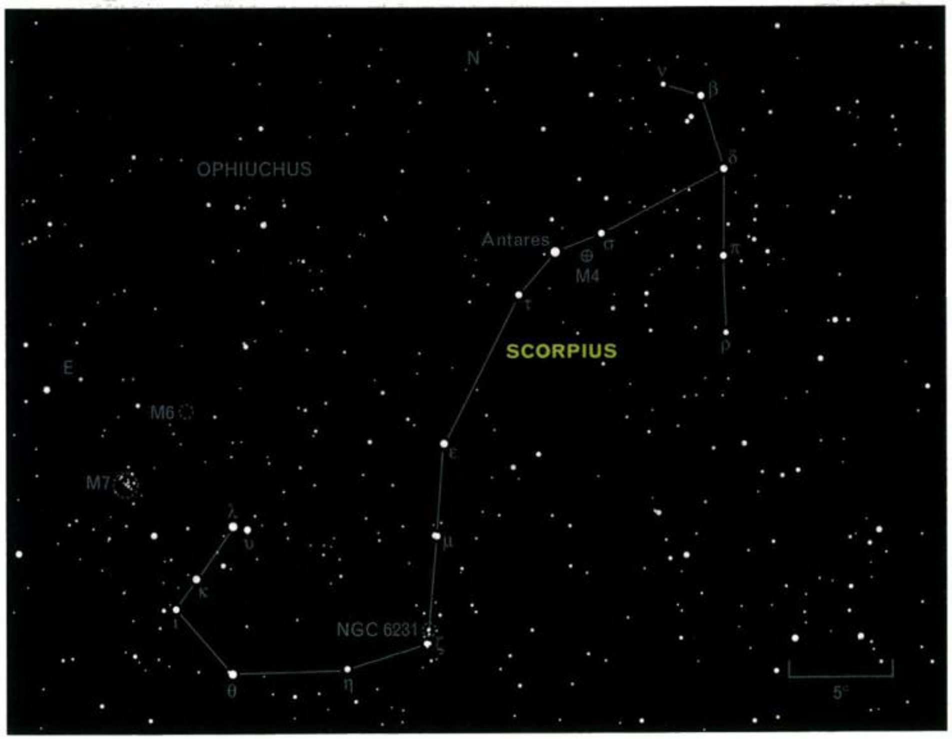
Few regions of the sky can match the splendors of the summer Milky Way. Dazzling star clusters and colorful nebulae combine to make it a fertile stomping ground for any deep-sky observer. For those who embrace brilliant star clusters, there's no better place to explore than Scorpius the Scorpion, which holds three of the finest examples in the heavens.

Begin your search with 1st-magnitude Antares, the star marking the heart of the scorpion. From there head 1.3° west to find M4, a globular cluster containing a few hundred thousand stars. At magnitude 5.8, the cluster glows brightly enough to see with the naked eye from a dark site. M4 holds two notable distinctions: It lies closer to a 1st-magnitude star than any other Messier object and, at a distance of 7,200 light-years, it ranks as the closest globular cluster to Earth. A 6-inch telescope shows dozens of stars scattered loosely across the cluster's face.

The scorpion's two most spectacular open clusters lurk in the southern part of Scorpius. Scan 5° northeast of Lambda (λ) Scorpii — the 1.6-magnitude star that forms the scorpion's stinger — to find M7. At a distance of 900 light-years, it's among the dozen nearest open clusters. That helps explain its brightness (it shines at magnitude 3.3) and large size (it spans more than 1°).

M6 lies 4° northwest of M7. It's twice as far away as its neighbor and appears smaller and fainter. Still, at magnitude 4.2 and with a diameter of 0.5°, it's an easy naked-eye object. Both clusters appear best with binoculars or a small telescope at low power. Larger scopes and higher magnifications degrade the view by making them appear as little more than rich starfields.

Bill and Sally Fletcher



S	M	T	W	T	F	S
		1	2	3	4	5
◑	7	8	9	10	11	12
●	14	15	16	17	18	19
20	◐	22	23	24	25	26
27	28	○	30	31		

EDT

2 **5 P.M.**
The moon passes 4° north of Jupiter

5 **6 A.M.**
Mercury is in superior conjunction

8 **4 A.M.**
Venus passes 0.8° north of Saturn (morning)

15 **1 A.M.**
The moon passes 5° south of Neptune

16 **noon**
The moon passes 5° south of Uranus

17 **4 A.M.**
The moon passes 0.3° north of Mars

25 **9 P.M.**
Mercury passes 0.4° north of Jupiter (evening)

26 **8 P.M.**
The moon passes 4° north of Saturn

30 **7 A.M.**
Mercury passes 0.2° north of Regulus (evening)
9 A.M.
The moon passes 4° north of Jupiter
9 P.M.
The moon passes 5° north of Mercury

AUG

Prepare for a Martian Invasion

Backyard astronomers around the world eagerly anticipate this year's record-setting apparition of Mars. The Red Planet comes closer to Earth and appears brighter in our sky this month than at any time in the past 2,000 years. Shining at magnitude –2.9, Mars will dominate the summer sky for weeks, even outshining mighty Jupiter. Mars lies closest to Earth on August 27, 2003, when it moves to within 34.65 million miles (55.76 million kilometers) of our planet. The actual opposition of Mars occurs 32 hours later, on August 28, placing Mars at its best for centuries. What makes this opposition great is that it nearly coincides with Mars's perihelion, its closest point to the sun. This occurs on August 30, just two days after opposition.

Consequently, this year Mars appears the largest it has ever appeared in Earth-bound telescopes. Its apparent diameter will reach 25.13". Mars will not reach this apparent size again until the year 2208 and will not surpass it until 2287. Compare this with the previous opposition of Mars in 2001, when the planet reached an apparent diameter of 20.8" — this year surpasses that by 20 percent.

The best part of this year's martian apparition begins in May when the planet lies in Capricornus. This constellation remains low for most observers in the Northern Hemisphere and Earth's atmosphere will adversely affect the quality of the view. The farther south you live, the better off you will be. By May 8 the disk of Mars spans more than 10". At this apparent size, Mars begins to reveal surface detail in small telescopes. Autumn begins in the northern hemisphere of Mars during May, so the northern polar cap will be small. Look for the broad, delta-shaped Syrtis Major region. Also note the planet's gibbous phase. Mars stays above 10" in apparent diameter until mid-December.

Steve Lee (University of Colorado), Jim Bell (Cornell University), Mike Wolff (STScI), and NASA

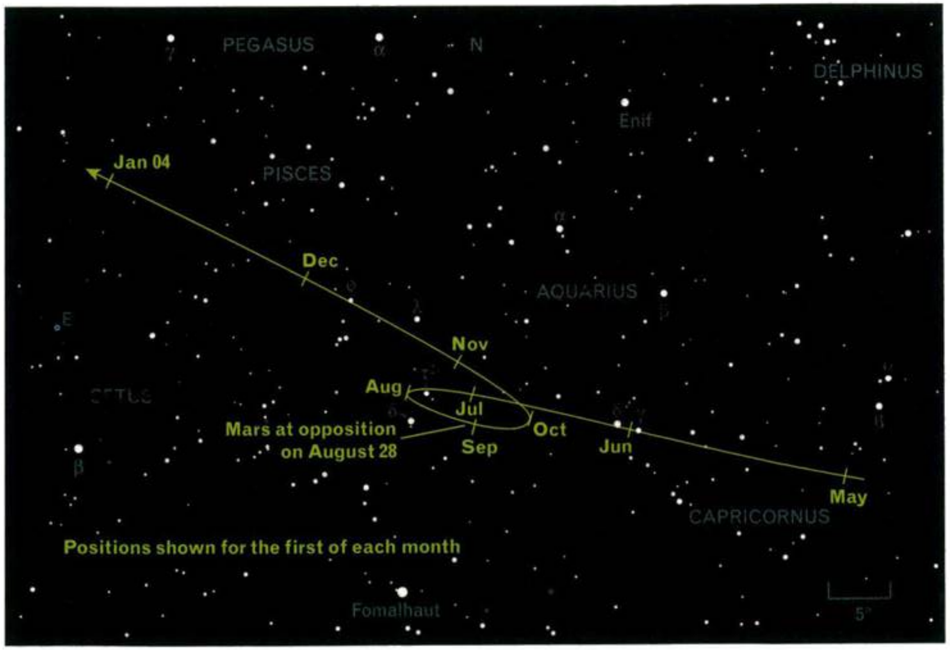
The eastward track of Mars carries it into Aquarius in June, and it passes 3° south of Uranus on the 20th. Its eastward motion slows to a halt at the end of July and it begins its retrograde loop, traveling westward, brought on by Earth beginning to catch up with the Red Planet as it prepares to overtake Mars on opposition day. Such a bright planet will utterly transform the appearance of Aquarius, whose brightest star manages a magnitude of just 2.9.

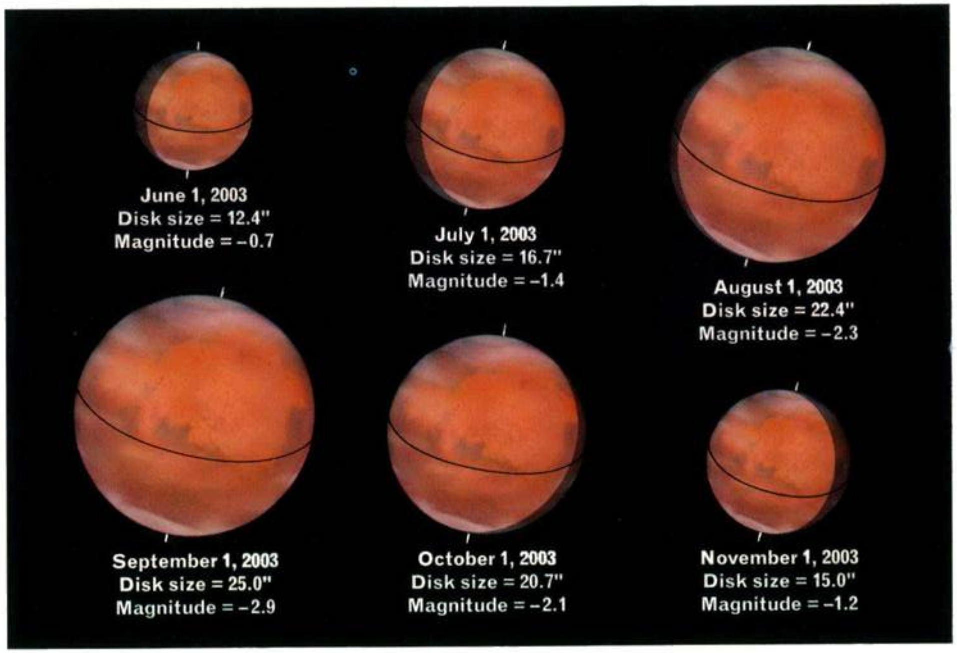
Around the time Mars reaches its equinox in May, the southern polar cap will be near its maximum diameter. As the springtime sun starts to hit the southern cap in June and July, it begins to shrink as the polar ices vaporize. Mars reaches a diameter of 20" on July 19 and remains larger than this until October 4. This coincides closely to the period when Mars shines brighter than magnitude –2.0.

Prior to opposition, Mars rules the morning sky. Take advantage of this period, from May through August, because Mars usually has an unpleasant surprise later in its apparitions when it shines in the evening. It has the tendency to develop planet-wide dust storms that can obscure most, if not all, details on the planet. During the 2001 apparition, a dust storm obscured the planet for weeks. Dust storms can develop in a number of regions and during any martian season, though historically they seem to peak during the martian southern summer. Summer begins there in late September.

Mars reaches opposition on August 28, when its southern hemisphere tips in our direction (as it does throughout most of the year). So unlike the 2001 apparition, we get a good view of the southern polar cap this time around, though it will be shrinking rapidly by late August and September. Opposition occurs with Mars well south of the ecliptic, standing 4° west of the 3rd-magnitude star Delta (δ) Aquarii.

Following opposition Mars becomes an evening object. By the end of September, its western trek slows to a halt and the planet resumes its normal easterly path. The distance between Earth and Mars increases steadily and the Red Planet begins to fade and shrink in size. By October 3, Mars has diminished to 20.2" in apparent diameter, which represents the maximum size it will reach at its next opposition in November 2005. You'll have to wait until July 2018 before Mars achieves anything approaching this year's show. It will then span 24.3".


PEGASUS
N
DELPHINUS
Enif
Jan 04
PISCES
Dec
AQUARIUS
E
Nov
CETUS
Aug
Jul
Mars at opposition
on August 28
Oct
Sep
Jun
May
CAPRICORNUS
Positions shown for the first of each month
Fomalhaut
5°


June 1, 2003
Disk size = 12.4"
Magnitude = –0.7
July 1, 2003
Disk size = 16.7"
Magnitude = –1.4
August 1, 2003
Disk size = 22.4"
Magnitude = –2.3
September 1, 2003
Disk size = 25.0"
Magnitude = –2.9
October 1, 2003
Disk size = 20.7"
Magnitude = –2.1
November 1, 2003
Disk size = 15.0"
Magnitude = –1.2

S	M	T	W	T	F	S
					1	2
3	4	◑	6	7	8	9
10	11	●	13	14	15	16
17	18	◐	20	21	22	23
24	25	26	○	28	29	30
31						

EDT

4 **10 A.M.**
Neptune is at opposition

11 **9 A.M.**
The moon passes 5° south of Neptune

12 **8 P.M.**
The moon passes 5° south of Uranus

13 Perseid meteor shower peaks
1 P.M.
The moon passes 1.9° north of Mars

14 **5 P.M.**
Mercury is at greatest eastern elongation (27°, evening)

18 **2 P.M.**
Venus is in superior conjunction

22 **6 A.M.**
Jupiter is in conjunction with the sun

23 **10 A.M.**
The moon passes 4° north of Saturn

24 **6 A.M.**
Uranus is at opposition

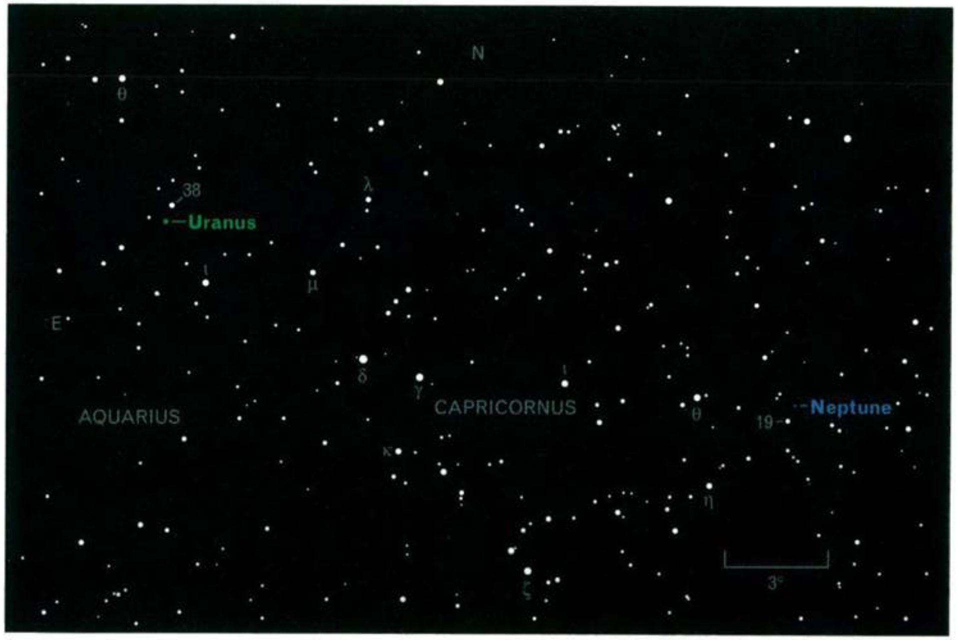
28 **2 P.M.**
Mars is at opposition
9 P.M.
The moon passes 9° north of Mercury

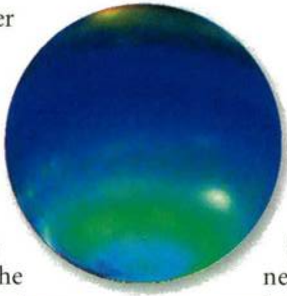
SEP

Spy the Distant Gas Giants

Two planets that span four times the size of Earth were not even known prior to 1781. In that year, Britain's William Herschel discovered the planet that became known as Uranus. Neptune was found in 1846. Uranus is on its third orbit of the sun since its discovery, while Neptune has yet to complete a single orbit since its discovery.

Both planets reach opposition in August: Neptune on the 4th and Uranus on the 24th. You can rediscover these planets for yourself. Both currently lie in the summer sky, Neptune in Capricornus the Sea-Goat and Uranus in Aquarius the Water Bearer.

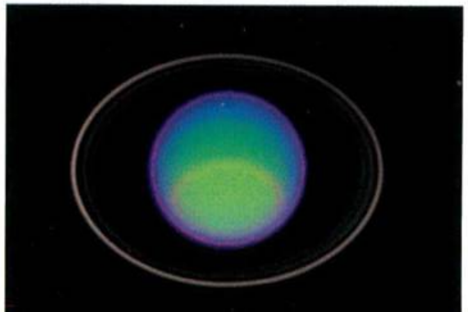




Uranus, the closer and brighter of the two, can be spotted in binoculars. The challenge is identifying the correct object through hand-held binoculars. Look for the 4.3-magnitude star Iota (ι) Aquarii, which lies 5° northeast of Delta (δ) Capricorni, the bright star that marks the eastern end of the Sea-Goat. Uranus lies 2.5° northeast of Iota Aquarii at opposition,

Neptune appears fainter than Uranus. While it can be viewed in binoculars, a telescope will make finding it easier. Neptune shines at magnitude 7.8 and lies in central Capricornus. Unfortunately, no bright stars lie nearby to aid the search. On a good night, the 4th-magnitude star Theta (θ) Capricorni should be easy to find. At opposition on August 4, Neptune

Once you have found each planet, you might wonder what there is to see. Uranus has an opposition distance from Earth of 1.77 billion miles (2.85 billion km), so few scopes will show any detail. It displays a bland disk 3.7" across with a distinct blue-green hue. Neptune lies 2.70 billion miles (4.35 billion km) away at its opposition. At this distance Neptune musters a 2.3"-



h photos: NASA/STScI

Exploring the Autumn Sky

The cool nights of autumn are here to remind us that the chill of winter is not far off. Along with the cool air, the brilliant stars of the summer triangle descend in the west to be replaced with a rather bland-looking region of sky. But don't let initial appearances deceive you. Hidden in the fall sky are gems equal to those of summertime.

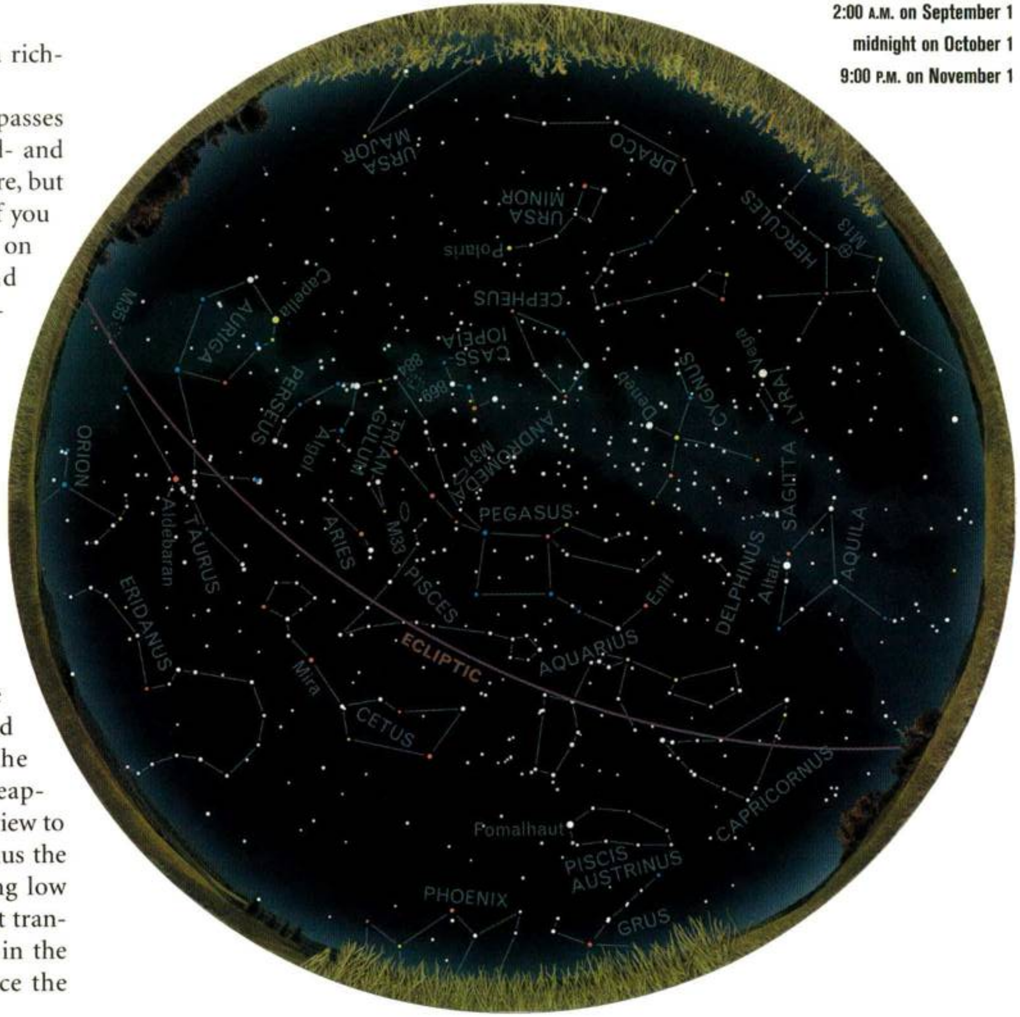
The Big Dipper swings low this season, and for parts of the southern United States it actually sets. Cassiopeia, a group of five bright stars in the form of a "W" or "M," reaches its culmination overhead, the same point the Dipper reached six months ago. To the east of Cassiopeia, Perseus rises high. Nestled between these two groups is the wonderful Double Cluster — NGCs 869 and 884 — a fantastic sight in binoculars or a low-power telescope.

Our view to the south of the Milky Way is a window out of the disk of our galaxy in the opposite direction to that visible in spring. This direction allows us a good look at the Local Group of galaxies. Due south of Cassiopeia lies the Great Andromeda Galaxy (M31), a 4th-magnitude smudge of light that passes overhead on November evenings. Farther south lies M33, a large, sprawling face-on spiral best seen in binoculars or a rich-field scope.

The Great Square of Pegasus passes just south of the zenith. Four 2nd- and 3rd-magnitude stars form the square, but few stars can be seen inside of it. If you draw a line between the two stars on the right side of the square and extend it southward, you'll find 1st-magnitude Fomalhaut in Piscis Austrinus the Southern Fish. Fomalhaut appears as the solitary bright star low in the southern sky.

Well to the east of the square lies the Pleiades star cluster (M45) in Taurus the Bull, which reminds us winter lurks not too far in the future. By late evening in October and early evening in December, Taurus and Orion the Hunter are clear of the horizon and Gemini the Twins is rising in the northeast. In concert with the reappearing winter constellations, the view to the northwest sees summer's Cygnus the Swan and Lyra the Harp swinging low and about to set. Autumn is a great transition period, both on Earth and in the sky, and a fine time to experience the subtleties of these constellations.

The all-sky map shows how the sky looks at
2:00 A.M. on September 1
midnight on October 1
9:00 P.M. on November 1


URSA MAJOR
DRACO
URSA MINOR
Polaris
HERCULES
M13
CEPHEUS
CASS-IOPEIA
Vega
LYRA
CYGNUS
Deneb
M35
AURIGA
Capella
PERSEUS
884
869
ANDROMEDA
M31
Algol
TRIAN-GULUM
M33
PEGASUS
SAGITTA
ORION
TAURUS
Aldebaran
ARIES
PISCES
DELPHINUS
Altair
AQUILA
Enif
ERIDANUS
Mira
ECLIPTIC
AQUARIUS
CETUS
CAPRICORNUS
Fomalhaut
PISCIS AUSTRINUS
PHOENIX
GRUS

S	M	T	W	T	F	S
	1	2	◑	4	5	6
7	8	9	●	11	12	13
14	15	16	17	◐	19	20
21	22	23	24	○	26	27
28	29	30				

EDT

7 **3 P.M.** The moon passes 5° south of Neptune

9 **2 A.M.** The moon passes 5° south of Uranus
9 A.M. The moon passes 1.2° north of Mars

10 **10 P.M.** Mercury is in inferior conjunction

19 **11 P.M.** The moon passes 5° north of Saturn

23 **7 A.M.** Equinox (northern autumn/southern spring begins)
midnight The moon passes 4° north of Jupiter

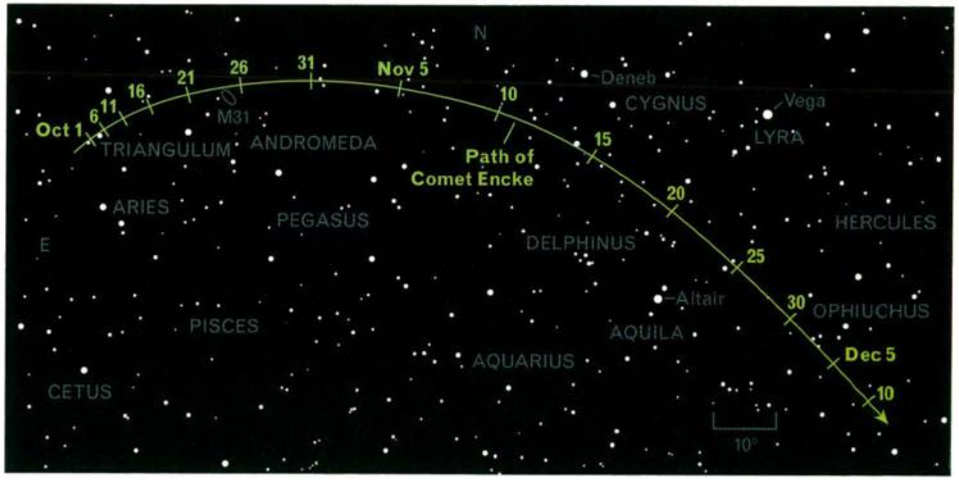
24 **1 P.M.** The moon passes 5° north of Mercury

26 **8 P.M.** Mercury is at greatest western elongation (18°, morning)

OCT

The Return of Comet Encke

Everyone knows Edmond Halley gained immortality when he predicted that a certain comet would return to view in 1758, and it did. Far fewer people remember Johann Encke, who put his stamp on the heavens when he calculated the 3.3-year-long orbit of a different periodic comet. Although the man and his comet – officially known as 2P/Encke – have remained in relative obscurity, that could change this year. October and November will see the comet put on a nice display in the evening sky, coming close to naked-eye visibility. Even more exciting, a NASA spacecraft will fly past the comet at the same time, returning the most detailed observations yet of a comet's nucleus.



For backyard observers, the best viewing will be on evenings from mid-October to the end of November. Throughout this period, Encke will be pulling closer and closer to the sun. The sun's heat will make the comet outgas at a greater rate, causing it to brighten from about 11th magnitude in mid-October to 6th or 7th magnitude by late November.

Encke reaches its peak elevation for Northern Hemisphere observers around November 10, when it lies nearly overhead as evening twilight ends. The following week to ten days should be prime viewing as the waning moon exits the early evening sky. Use the map above to track Encke's progress. Note its close pass by the Andromeda Galaxy (M31) in late October and its track along the spine of the Milky Way in Cygnus during mid-November.

That's the same time that NASA's Comet Nucleus Tour (CONTOUR) spacecraft will reach Encke. It will fly just 60 miles (100 kilometers) from the comet's nucleus. A 10-inch-thick, layered dust shield made of Nextel and Kevlar fabric will protect the spacecraft's four scientific instruments, which will take detailed photos and analyze the comet's chemical makeup. After the Encke encounter, CONTOUR will head on to Schwassmann-Wachmann 3, where it will perform similar studies in June 2006.

Jim Scotti (Spacewatch/University of Arizona)

The Hunter's Fiery Gift

The Orionid meteor shower reaches its peak in the early morning hours of October 22. Although not as prolific as the more famous Perseid and Geminid meteor showers, the Orionids usually put on a good show, producing up to 20 meteors per hour. And this year the moon will not interfere, while both the Perseids and Geminids battle a nearly full moon.

The meteors are actually tiny bits of cosmic dust that burn up from friction when they slam into Earth's upper atmosphere. The Orionids hit the atmosphere at 41 miles per second, producing fast, bright meteors that often leave glowing trails. The shower gets its name from the constellation Orion the Hunter, from where the meteors appear to radiate.

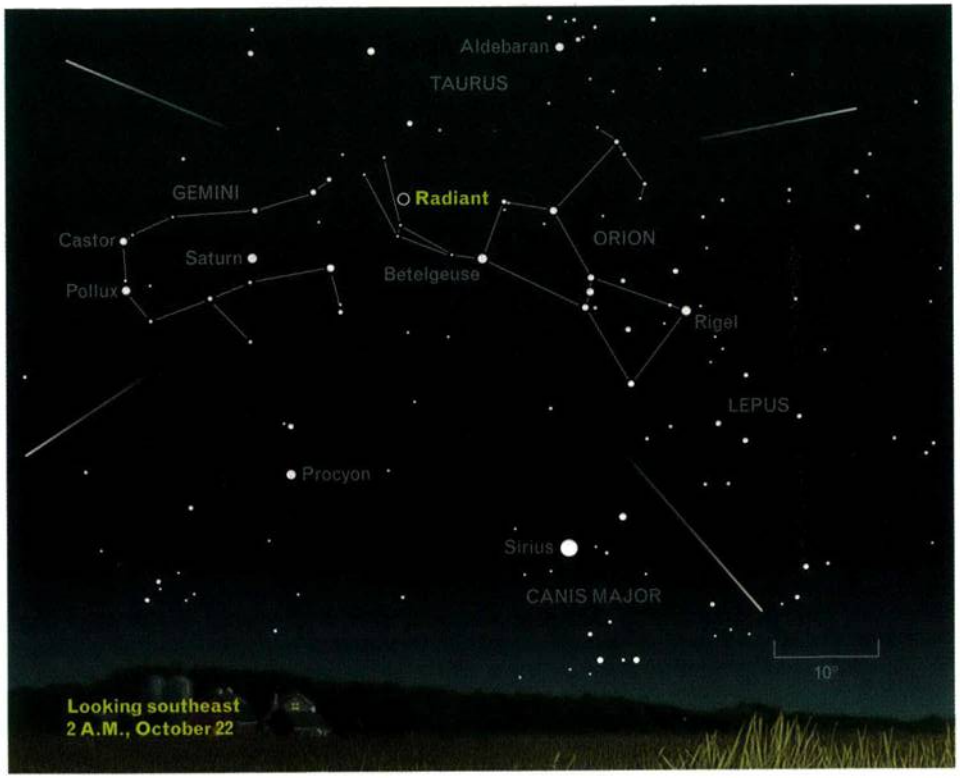
The best time to watch is before morning twilight begins on the 22nd. That gives Orion time to climb higher in the sky and puts you on Earth's leading hemisphere. (Just as a car's front windshield picks up more rain than the rear, Earth sweeps up more debris in the hours after midnight.) To see the shower at its best, observe from a rural location where the lights of the city won't wash out the fainter meteors.

The dust stream that gives us this meteor shower was born of comet Halley. Each time Halley passes near the sun (it last graced the inner solar system in 1986), the sun warms the comet's icy nucleus. This causes the ice to turn directly to gas and releases dust in the process. The dust then forms the tail of the comet and eventually spreads out along Halley's entire orbit. When Earth runs into this cometary debris each October, we see the meteor shower. (We hit another part of the stream in early May, giving rise to the Eta Aquarid meteor shower.)

METEOR SHOWERS FOR 2003

Name	Peak date	Moon's phase	Prospects
Quadrantids	January 4	New moon	Excellent
Lyrids	April 22	Last quarter	Poor
Eta Aquarids	May 5	Waxing crescent	Excellent
Perseids	August 13	Full moon	Poor
Orionids	October 22	Waning crescent	Excellent
Leonids	November 18	Waning crescent	Fair
Geminids	December 14	Waning gibbous	Poor

Wallace Baldwin



Looking southeast
2 A.M., October 22

S	M	T	W	T	F	S
			1	◑	3	4
5	6	7	8	9	●	11
12	13	14	15	16	17	◐
19	20	21	22	23	24	○
26	27	28	29	30	◑	

EDT

3 **6 P.M.**
Venus passes 3° north of Spica (evening)

4 **8 P.M.**
The moon passes 5° south of Neptune

6 **6 A.M.**
The moon passes 5° south of Uranus
11 A.M.
The moon passes 1.1° south of Mars

13 **11 A.M.**
Asteroid Pallas is at opposition

17 **9 A.M.**
The moon passes 5° north of Saturn

21 **7 P.M.**
The moon passes 4° north of Jupiter

22 Orionid meteor shower peaks

25 **6 A.M.**
Mercury is in superior conjunction

26 **3 P.M.** EST
The moon passes 0.08° south of Venus

NOV

The Vanishing Moon, Part Two

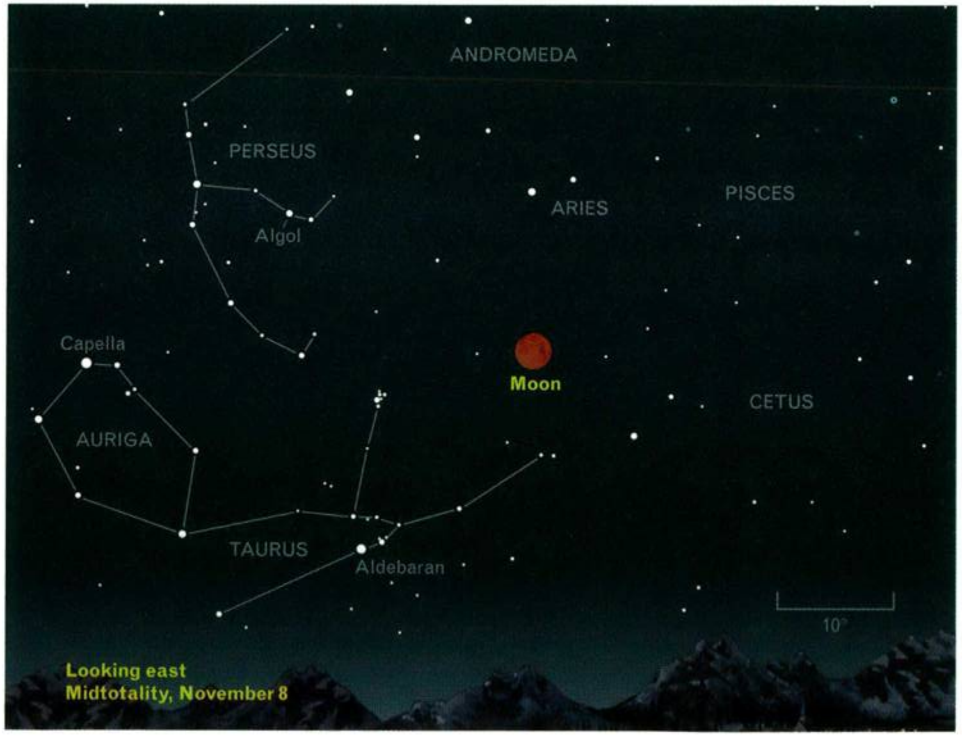
A copper-colored moon stands high in the sky, lending a warm, soft glow to the chilly autumn landscape below. Such will be the scene on the night of November 8/9 when, for the second time this year, the full moon traverses Earth's shadow. Barring cloudy weather, observers across North and South America, Europe, Africa, and western Asia will behold a total lunar eclipse.

Unlike May's lunar eclipse, however, totality will be a fleeting affair. From start to finish, the total phase will endure for only 24 minutes. That's because the moon's south polar region barely makes it into the southern portion of Earth's umbral shadow. As you watch totality unfold, expect the southern part of the moon to remain noticeably brighter than the northern part.

No matter how dark the moon gets, you'll be sure to notice its color. During totality, the moon usually appears some shade of red, anywhere from a bright copper-red to a dark reddish brown.

At first the color may seem surprising — after all, how can light get into our planet's shadow? If Earth were an airless planet, the shadow would be pitch black and the eclipsed moon would seem to vanish. But our atmosphere acts like a filtered lens, bending red light into the shadow and scattering out blue light.

If you were an astronaut standing on the moon during totality, you would see Earth eclipsing the sun. Earth would appear as a dark disk surrounded by a brilliant ring of red — our atmosphere glowing with the light of all the planet's sunrises and sunsets. It's this light we see bathing the moon during totality.



Looking east
Midtotality, November 8

Totality begins at 8:07 P.M. EST (5:07 P.M. PST) on November 8 — a little more than 90 minutes after the partial phase commences — and wraps up at 8:31 P.M. EST (5:31 P.M. PST). In the Eastern Hemisphere, observers will see the eclipse during the early morning hours of the 9th.

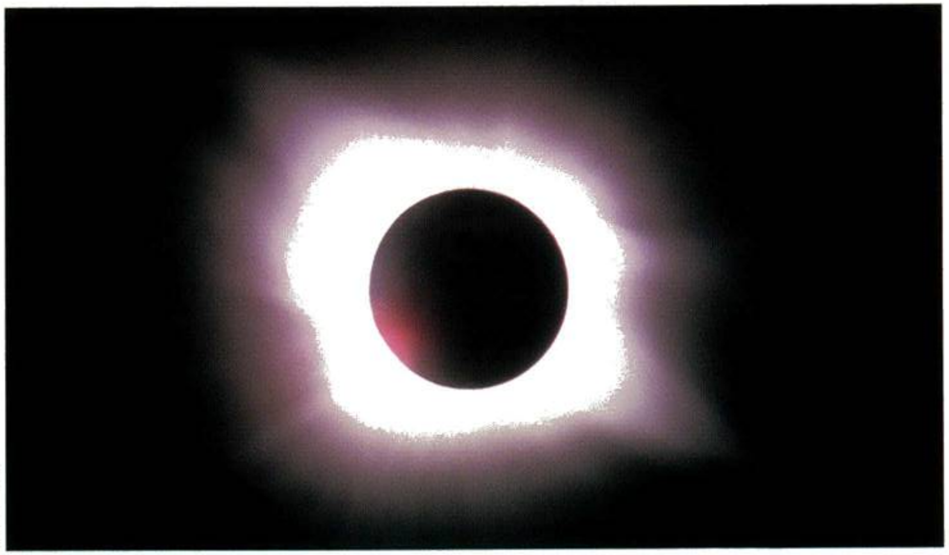
Totality Reaches for the Pole

The second solar eclipse of 2003 proves a bit more interesting than the first, even though it is less accessible. On November 23/24, a total eclipse will cross the vast icy desert of Antarctica. A few lucky people at scattered research stations will join with native penguins to see day turn to night for up to two minutes.

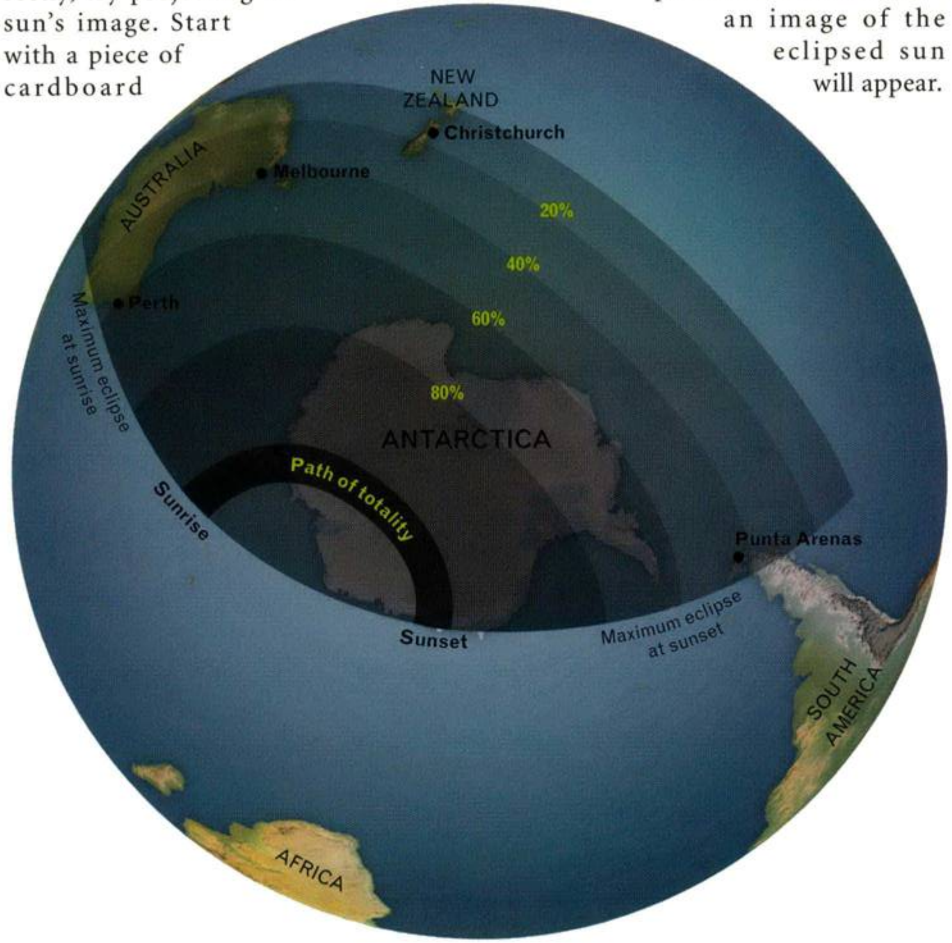
Although Antarctica may not seem all that enticing, a wide area of the Southern Hemisphere will witness a partial eclipse. Residents in most of Australia, the South Island of New Zealand, and the southern tip of South America will see the moon block part of the sun from view.

Viewing the sun during a partial eclipse poses a grave risk to your eyesight — if you don't take proper precautions. To view the eclipse directly, use a safe solar filter. A #14 welder's glass works well — look for one at a welding supply store. Mylar and metal-on-glass filters also let you view the eclipse safely. To watch an eclipse indirectly, try projecting the sun's image. Start with a piece of cardboard and cut a hole in it. Then tape some aluminum foil over that hole and poke a tiny hole in the foil. During the eclipse, stand with your back to the sun and let sunlight pass through the pinhole onto another piece of cardboard, where an image of the eclipsed sun will appear.

Park Chun-Ki



Jason Paschal


NEW ZEALAND
Christchurch
AUSTRALIA
Melbourne
Perth
20%
40%
60%
80%
ANTARCTICA
Maximum eclipse at sunrise
Sunrise
Path of totality
Sunset
Punta Arenas
Maximum eclipse at sunset
SOUTH AMERICA
AFRICA

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	●
9	10	11	12	13	14	15
◐	17	18	19	20	21	22
○	24	25	26	27	28	29
◑						

EST

1 **1 A.M.**
The moon passes 5° south of Neptune

2 **10 A.M.**
The moon passes 5° south of Uranus

3 **4 A.M.**
The moon passes 3° south of Mars

8 **8 P.M.**
Total lunar eclipse

10 **2 A.M.**
Venus passes 4° north of Antares (evening)

13 **2 P.M.**
The moon passes 5° north of Saturn

18 Leonid meteor shower peaks
11 A.M.
The moon passes 4° north of Jupiter

23 **6 P.M.**
Total solar eclipse

25 **1 P.M.**
The moon passes 2° south of Venus

28 **9 A.M.**
The moon passes 5° south of Neptune

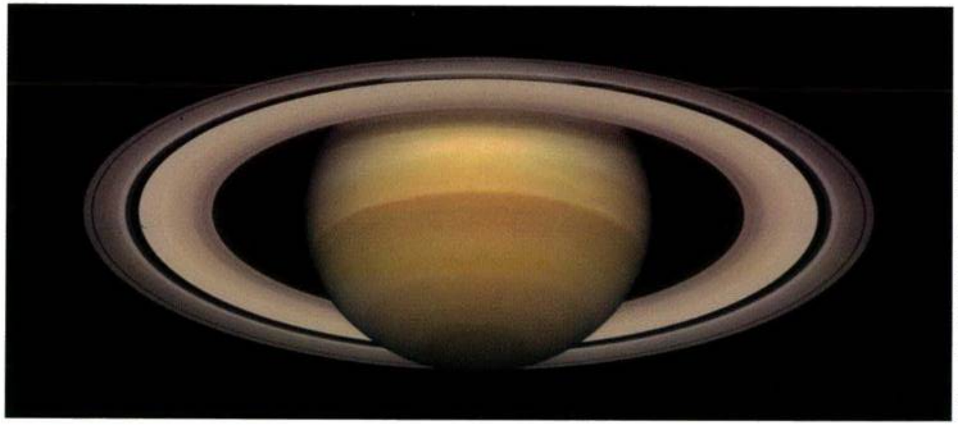
29 **5 P.M.**
The moon passes 5° south of Uranus

DEC

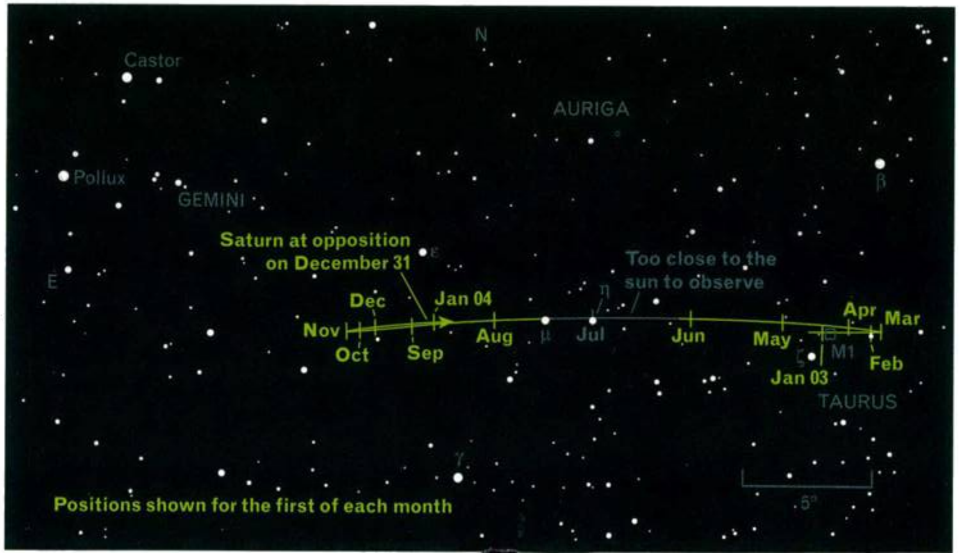
Saturn: A Year-End Jewel

On New Year's Eve, Saturn reaches a point exactly opposite the sun in our sky. Such oppositions place planets in the sky all night, from sunset to sunrise. Saturn spends the last half of 2003 in Gemini the Twins, and at the end of the year it lies in the western half of that constellation. Shining at magnitude −0.5, it easily beats out Gemini's two brightest stars, Castor and Pollux.

At midnight during December, Saturn stands high in the sky – its highest point in the past 30 years for Northern Hemisphere observers, passing near the zenith for those at mid-northern latitudes.



NASA and the Hubble Heritage Team (STScI/AURA)



Positions shown for the first of each month

Saturn's easterly motion against the background stars through August and September slows to a halt in late October as Earth begins to overtake the distant planet. As we approach opposition, Saturn begins its retrograde, or westerly, path against the stars in Gemini.

Saturn lies 748 million miles (1.20 billion km) from Earth at opposition. Although its physical size comes close to that of Jupiter, its disk appears only half the size because it's at almost double Jupiter's distance. Any telescope will show the planet's 21"-diameter disk. Yet Saturn's principal attraction remains its rings that, at least lengthways, bring Saturn's overall size to one comparable to Jupiter's girth.

Saturn reaches perihelion, the closest point to the sun in its 29.5-year orbit, on July 26. In addition, the southern face of the rings now tilt at their widest since they began opening up to our view in 1995. This places Saturn at its brightest in some 30 years. The next ring-plane crossing takes place in 2009, and following that we will see the north side of the rings again.

Exploring the Winter Sky

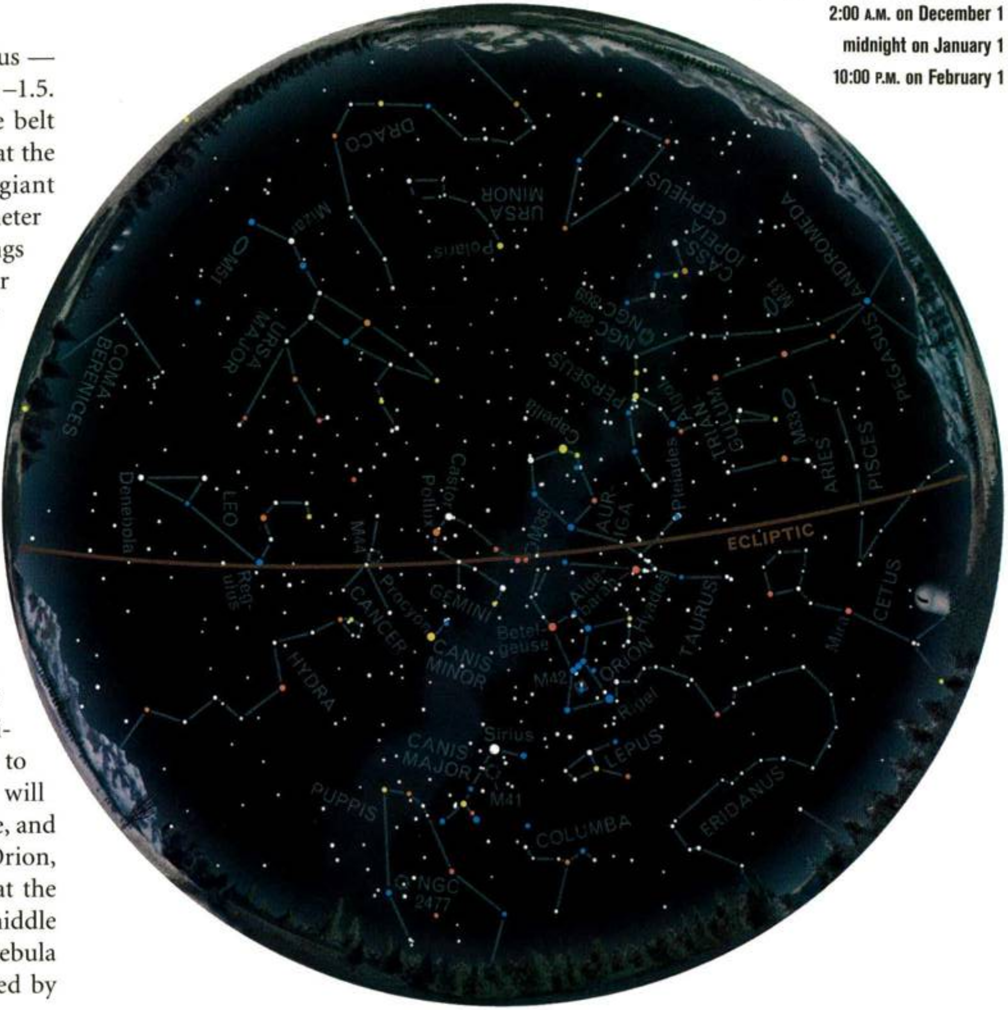
Have you ever become lost in an unfamiliar city or state? Chances are you used two things to get around — a map and some signposts. In much the same way, these two items can help you find your way around the sky in any season. Fortunately, in addition to our seasonal sky charts, there are two major signposts provided for us in the sky. Each seasonal description will talk about the first one — the Big Dipper: a group of seven bright stars in the constellation Ursa Major.

Winter sees the Big Dipper in the northeast, with its triple-starred handle pointing toward the horizon and the four-starred bowl standing highest. The entire sky rotates around Polaris, a 2nd-magnitude star found by extending a line from the uppermost pair of stars in the bowl across the sky to the Dipper's left.

Turn so your back is to the Dipper and you'll be facing the winter sky. The second great signpost in the sky, Orion the Hunter, is central to the brilliant scene. Three closely spaced stars in a straight line form the unmistakable belt of Orion. Extending the imaginary line joining these stars to their upper right leads to Taurus the Bull, and its orangish 1st-magnitude star, Aldebaran. Reverse the direction of your gaze to the belt's lower left and you cannot miss Sirius — brightest in all the sky at magnitude –1.5.

Move now perpendicular to the belt from its westernmost star and find at the upper left of Orion the red supergiant star, Betelgeuse, 800 times the diameter of the sun. Continuing this line brings you to a bright pair of stars, Castor and Pollux. Two lines of fainter stars extend from this pair back toward Orion — these represent Gemini the Twins. Near the northeastern corner of this constellation lies the beautiful open star cluster, M35.

Above Orion and nearly overhead on winter evenings is brilliant Capella in Auriga. Extending a line through the shoulders of Orion to the east leads you to Procyon in Canis Minor. Once you have these principal stars mastered, using our chart to discover the fainter constellations will be a whole lot easier. Take your time, and enjoy the journey. Before leaving Orion, however, aim a pair of binoculars at the line of stars below the belt — the middle one is actually the glorious Orion Nebula (M42), a stellar nursery illuminated by bright, newly formed stars.


DRACO
URSA MINOR
Polaris
CEPHEUS
CASSIOPEIA
ANDROMEDA
M31
PEGASUS
Mizar
M51
URSA MAJOR
NGC 869
NGC 884
PERSEUS
Algol
TRIANGULUM
M33
ARIES
PISCES
COMA BERENICES
LEO
Denebola
Regulus
Castor
Pollux
Capella
M35
AURIGA
Pleiades
ECLIPTIC
CETUS
Mira
M44
CANCER
Procyon
GEMINI
Betelgeuse
Aldebaran
Hyades
TAURUS
HYDRA
CANIS MINOR
M42
ORION
Rigel
Sirius
LEPUS
CANIS MAJOR
M41
ERIDANUS
PUPPIS
COLUMBA
NGC 2477

The all-sky map shows how the sky looks at
2:00 A.M. on December 1
midnight on January 1
10:00 P.M. on February 1

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	●	9	10	11	12	13
14	15	◐	17	18	19	20
21	22	○	24	25	26	27
28	29	◑	31			

EST

1 **11 A.M.**
The moon passes 4° south of Mars

9 **1 A.M.**
Mercury is at greatest eastern elongation (21°, evening)

10 **5 P.M.**
The moon passes 5° north of Saturn

11 **midnight**
Pluto is in conjunction with the sun

14 Geminid meteor shower peaks

15 **11 P.M.**
The moon passes 4° north of Jupiter

22 **2 A.M.**
Solstice (northern winter/southern summer begins)

25 **11 A.M.**
The moon passes 3° south of Venus

26 **8 P.M.**
Mercury is in inferior conjunction

30 **2 A.M.**
The moon passes 4° south of Mars
2 A.M.
Venus passes 1.9° south of Neptune (evening)

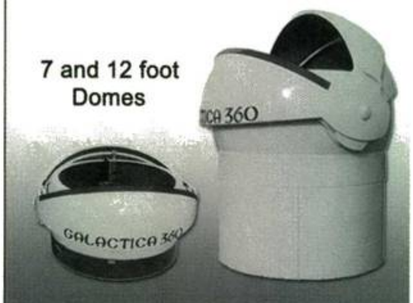
31 **4 P.M.**
Saturn is at opposition

Refracting Telescope Kit
Celestial Sphere Kit
PROJECT STAR
Science Materials · Hands-on
Cardboard Spectrometer Kit
Holographic Diffraction Grating

Learning Technologies, Inc.
40 Cameron Avenue • Somerville, MA 02144
Tel: 800-537-8703 • Fax: 617-628-8606
E-mail: starlab@starlab.com • www.starlab.com

GALACTICA 360

7 and 12 foot Domes



www.galactica360.com
tel. 604.530.8746 fax. 604.533.4766

ATOMIC TIME™

1010 Jorie Blvd. #332 Oak Brook, IL. 60523

Tell time by the U.S. Atomic Clock -The official U.S. time that governs ship movements, radio stations, space flights, and warplanes. With small radio receivers hidden inside our timepieces, they automatically syncronize to the U.S. Atomic Clock (which measures each second of time as 9,192,631,770 vibrations of a cesium 133 atom in a vacuum) and give time which is accurate to 1 second every million years. Our timepieces even account automatically for daylight saving time, leap years, and leap seconds. Accept only the best, most precise, and reliable timepieces in the world, Atomic Time.

Atomic Time
0645R Digital Wall
Light/Dark Grey
12 or 24 hr. format
day, date, month
temp. alarm
10.5" x 7.5"
$29.95

Junghans MEGA
Atomic Carbon
Carbon Fiber case
sapphire glass
crystal lens, black
leather band, LCD
with day & date.
$239.20

Atomic Time
W102 Digital
Hour, minute, second, day, date,
blue polymer case
backlight, alarm &
stopwatch
$28.95

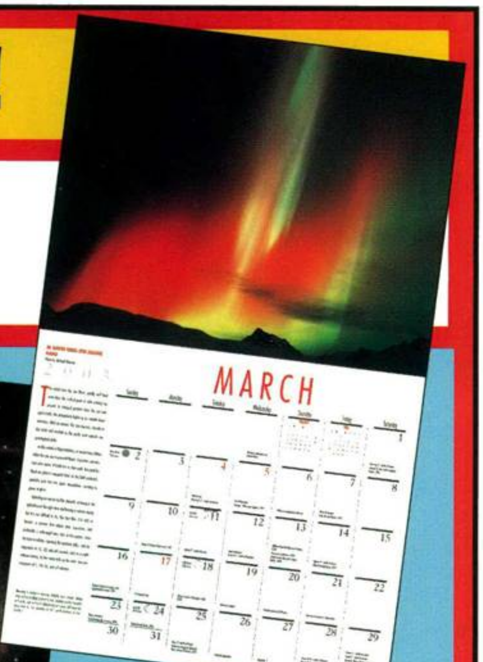
Atomic Dual Time-
Dual Alarm Clock
TLWA201
Available in black
or silver, backlit,
displays local time
and any world time
$45.00

1-800-985-8463
www.atomictime.com
30 Day Money-Back Guarantee
Call for our FREE Brochure

All items add $7.95 S/H
IL. res. add 6.75% sales tax

Ideal for your home or office!

Striking images of dramatic celestial observations include the Orion and Horsehead Nebulae, an Alaskan aurora, a total eclipse of the moon, and many more. Features data on viewing many celestial events and seasonal star charts. Recognizes national holidays. 13 x 10½. Item #68125

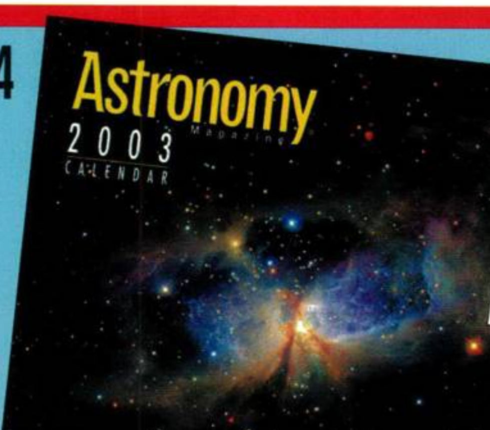


1-800-533-6644

Mon–Fri, 8:30am–5:00pm Central Time
Fax 262-796-1615 • Outside the U.S.
and Canada, call 262-796-8776

Order online:
astronomy.com

To order by mail: Send your order to: Kalmbach Publishing Co • Dept. U2077, 21027 Crossroads Circle • P.O. Box 986 Waukesha, WI 53187-0986



A3017AD

Include for shipping and handling:

Merchandise Total	Add for S&H
$15.00 or less	$4.95
$15.01-30.00	$5.50
$30.01-50.00	$6.50
$50.01-75.00	$7.50
over $75.01	$8.50

Canada add an additional $2.00, other foreign add an additional $5.00. For Wisconsin delivery, add 5% sales tax to total; Pennsylvania add 6% sales tax to total. For delivery in Canada add 7% GST to total. Payable in U.S. funds. Prices and availability subject to change.

Astronomy 2003 Calendar $11.99

U2077

Entry Level, 24 bit color,

Long exposure CCD Imaging

Starting at $369

SACIV $199

SAC Imaging

321-259-6498

www.sac-imaging.com

Knollwood Books

Your specialist in the sale of new, out-of-print, and rare astronomy-related books, magazines, ephemera, and other printed materials.

We operate a free search service & purchase select, printed astronomy-related materials.

Send us your list!

To receive our Fall 2002 catalog send $2 to:

PO Box 2206
Waukesha, WI 53147-2206
262-751-8350
(evenings after 6pm)

e-mail: books@wi.rr.com
www.knollwoodbooks.com

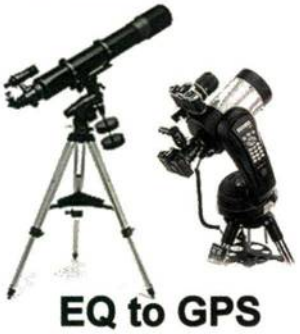
www.earthtreasuresmall.com

Exploration Encouraged

WEATHER STATIONS

Wireless & Cabled

TELESCOPES



EQ to GPS

MICROSCOPES

Beginner to Research grade

CELESTRON
MEADE
TELE VUE
DISCOVERY
LW SCIENTIFIC
DAVIS

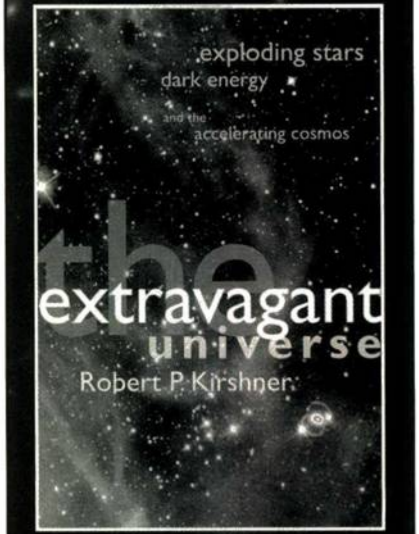
BINOCULARS

Birding, Nature, Sports & Astronomy

"FROM THE MOLECULAR TO THE INFINITE"

EARTH TREASURES
12 MAIN ST. KEENE, N.H. 03431
PHONE-1-800-550-7192 FAX-603-352-5119
info@earthtreasuresmall.com

Princeton Astronomy



The Extravagant Universe
Exploding Stars, Dark Energy, and the Accelerating Cosmos
Robert P. Kirshner

"This is a wonderful book on one of the hottest topics in science.... It presents a history of modern cosmology written in a very lively style with amusing personal stories that make the reading easy and entertaining."
—Bohdan Paczynski
Cloth $29.95

A Tribble's Guide to Space
Alan C. Tribble

"There is no better guide for a future rocket scientist or for anyone who just wants to understand what it means to be in space."
—*American Scientist*
New in paper $16.95

Shoemaker by Levy
The Man Who Made an Impact
David H. Levy

"[This] book should appeal to a wide audience of readers, including those seeking the personalities behind astronomy in the late 20th century."
—*Astronomy*
New in paper $16.95

Princeton University Press
800-777-4726
WWW.PUP.PRINCETON.EDU

Cool Gear for Cold Nights

Your telescope need not wait out the winter in a closet. With the right gear, cold-weather observing can be a rewarding experience.

by Maggie McKee

When it comes to observing, many of us are fair-weather friends. In the halcyon days of summer, when lollygagging tops our to-do lists, it's easy to spend whole nights sprawled on soft grass, gazing at the swirling heavens above. There are lightning bugs to watch, star parties to attend, Perseids to count. In summertime, the living — or at least the observing — is easy.

But as the air grows crisper and darkness begins to overtake the day, the urge to spend long, still hours outside drops with the falling mercury. We nest in our warmly lit homes, curl up under soft blankets, forsake the skies for the television. But ironically, some of the best observing falls on the coldest nights (clouds, the bane of the astronomer's existence, also trap heat near the Earth's surface). With a little preparation, now need not be the winter of our discontent. Here are a few tips to make cold-weather observing a pleasure.

John Marrari

WIN INSTANTLY
2002 OLYMPIC WINTER GAMES TRIPS & PRIZES
PowerBar
HIGH PERFORMANCE ENERGY BAR
VANILLA CRISP

Creature Comforts

Not to belabor the obvious, but the first (and second, and third...) thing you notice about cold-weather observing is that it is, well, cold. A forgotten hat or the wrong pair of boots can mean the difference between a productive night of stargazing and a hasty retreat. Light, water-resistant, breathable synthetics are now rated for temperatures in the triple digits below zero, so observers can endure the elements in relative comfort. But veterans don't rely on the ratings too heavily. They assume the wearer will be very active, not the kinetic equivalent of a couch potato, as most hobbyists are when they settle into observing. Be sure to buy coats and boots with temperature ratings well below the mercury level outside.

Also, as your mother has probably drilled into you, it's not the bulk of clothing that counts but the layering. Pockets of air between each layer keep your body heat from escaping into the ether, just as the air between two panes of glass insulates a home window.

Try starting with a good, light set of long underwear made of a porous material that soaks up and then re-evaporates sweat from your body. Although cotton soaks up moisture well, it may cool you too much, making wool blends a better option. Many companies also market silk and polyester skivvies of varying weights that resist odor-causing bacteria and mildew. These run about $45 per set, and can be found online at REI (www.rei.com), Land's End (www.landsend.com), and Cabela's (www.cabelas.com), among others. Some have turtleneck tops, which provide a little extra protection against both heat loss from the neck and icy blasts of air that can infiltrate even the tightest coat collars.

Next, don an oversized sweatshirt or sweater. Depending on the weather, you might end with a downy jacket or keep layering with fleece vests, ultimately ending up with a wind-resistant outer shell. Jacket/shell combinations sell for about $180 at the above-mentioned sites.

Though really chilly air can seep into your whole body, making it numb or so painful you wish it *were* numb, it's usually the extremities and head that feel the coldest. Hats are a must, and since mittens have more insulating dead-air space than do gloves, consider buying a pair with removable flaps so you can nimbly (as opposed to numbly) use your fingers to adjust a focus knob here or change an eyepiece there. Also, mittens are roomy enough to hold ingenious devices called hand warmers that generate heat when their contents interact with the oxygen in air. Slightly larger than a packet of fast-food ketchup, they can get almost uncomfortably toasty (typically around 130° Fahrenheit), so it's a good idea to keep a layer of material between them and your skin. Lasting up to ten hours, hand warmers (such as HotHands-2 by Heatmax) are a steal at around $2 each.

If you're going to be able to think *on* your feet, you've got to think *of* your feet. Nothing can dampen your spirits like cold, wet toes, and wool socks are ideal for winter observing because their fibers trap air well and don't absorb water easily. If it's really frosty, try doubling up with a liner pair (Wigwam sells an acrylic blend for about $8), and bring an extra pair of socks along in case the first get wet. As for shoes, many observers suggest getting oversized snowmobiler boots, rated for the lowest temperature you can afford. Getting a larger-than-normal size allows you to go wild with layers of socks, and gives you that all-important insulating air space. When you go to the sports shop, try the boots on with a couple of layers of socks so you can buy the most comfortable pair for your needs. For even more insulation between you and what can feel like permafrost below, bring along a plank of wood or a piece of thick plastic to stand on. Your feet will thank you for it.

Just being in the cold makes your body burn more calories to stay warm, so don't forget to eat a good meal before you head out, and bring along some munchies to refuel through the night. High-carb snacks like granola bars will give you a quick boost in energy (PowerBars are filling for about $1 each), while a thermos full of soup, hot water, or decaffeinated coffee or tea will thaw you out. You might think a strong cup of coffee or tea would perk you up for a long night of observing, but dangerously, caffeine increases the chance of frostbite by limiting the

Top: Nurture your body inside and out with high-carb snacks like PowerBars and with insulating layers of clothes. Left: Frost-busting dew removal kits, such as this one from Kendrick Astro Instruments, help your scope cope with the cold. *Astronomy:* Jim Forbes

HOTHANDS-2
HAND WARMER

Starlite
Rigel Systems

Top left: Keep your fingers toasty with hand warmers, which heat up when their contents are exposed to air. *Astronomy:* Jim Forbes **Top right: Red flashlights like this one by Rigel Systems let you read star charts without losing your eyes' adaptation to the dark.** *Astronomy:* Bill Zuback

blood's flow through the body.

Besides skipping the lattés, prevent frostbite by taking frequent refuge in your warm house or car, and set up your scope next to a hedge or wall, anything that will buffer you from the sometimes merciless wind. The wind will also dry out your skin, so bring along some lip balm and lather on some lotion before and after your session.

Obsessive-Compulsive Disorder is Underrated

If location is everything to real estate (and in many ways it is to astronomy as well), the three most important factors in a successful night of cold-weather observing are organization, organization, organization. When the temperature is so low you feel like you are inhaling tiny jagged icicles with every breath, you don't want to be bare-fingered when sorting through bags of equipment looking for the right eyepiece. A few efficient gadgets will also minimize the frustration of working swaddled in layers.

For seamless winter sessions, take a lesson from Goldilocks: Your telescope shouldn't be too hot or too cold, but just right. If you store it inside, let it sit outside for about two hours to equalize to the surroundings, but if frost is a problem, consider buying a dew remover kit, which also works on frost. These kits contain heating elements — they look like the Velcro bands doctors use to measure blood pressure — that wrap around various pieces of equipment. The slight increase in temperature melts the frost so that it can be wiped off easily. Kendrick Astro Instruments offers heaters of various sizes for around $50 (www.kendrick-ai.com). Also, try not to exhale onto your setup. The moisture in your breath can condense on the cooled surfaces and form frost.

Finally, there are a few items that make observing a breeze in any weather — but especially in the bone-chilling cold.

If you're observing in your backyard, set up a chair and a card or patio table to lay your gear on. If you travel to do your observing, consider getting a popular Roll-a-Table. Its slatted wooden top supports 125 pounds and rolls up into a long tube that weighs just 10 pounds. These sell for $37 at REI, and the companion Roll-a-Stool sells for $14.

Accessory cases are also time- and trouble-savers, keeping everything together in a James Bond-esque package (an added bonus for astronomers, who don't have a reputation for looking dangerous or cool). Orion sells cases in the $20-range with removable foam cut-outs that fit eyepieces, star diagonals, flashlights, and sundry other aids (www.telescope.com). You will appreciate having all of your accessories at your fingertips, and they will be better protected to boot. (But stay away from the martinis — shaken, not stirred — alcohol can lull you into feeling warmer than you really are, putting you at increased risk of frostbite, not to mention its effects on vision.)

Another must is a good set of star charts, and *Norton's Star Atlas and Reference Handbook* is an excellent source. In its 19th edition, it sells for $22 at Amazon.com. Other popular titles include *Sky Atlas* 2000.0 for $30, and *Uranometria* 2000.0 for $50.

Last but not least, a red flashlight for illuminating your star charts is crucial if you don't want to lose the "dark adaptation" that allows you to see fainter objects in the sky. The eye has two kinds of receptors: cones, which allow you to see under bright illumination and produce sharp images because they are in the center of vision; and rods, which take over under dim conditions and tend to make images look blurry. It takes up to twenty minutes for your eyes to adapt to the dark, so observing sessions are best conducted without ruining that hard-won acclimatization with a momentary flicker of a porch light or regular white flashlight. Since rods only respond to light in the blue-green range, red lights allow you to look between scope and star chart without shifting gears. BMW cars use red lights in their control panels, as did World War II airplanes.

"There are two drawbacks, though," says Patrick Cavanagh, a vision scientist at Harvard University. "None of the rods are in the center of your vision, so you can't look straight at a dim star — you have to look beside it," a familiar phenomenon to astronomers. Also, five percent of males and a quarter percent of females are blind to the color red, so red flashlights are of no use to observers in this category. "Those are the astronomers who take their BMWs back and drive Mercedes," says Cavanagh.

Rigel Systems makes a popular red LED flashlight with adjustable brightness controls called "Starlite" that sells for $26 (http://members.cox.net/rigelsys/flashlight.html). You can also make your own with a regular flashlight and any kind of red filter (cellophane, or car tail light repair tape, for example). The benefits of an LED (light emitting diode) are that it eats up very little current, so the batteries have a long and fruitful life, and the LED will never burn out. Pens with a red-light tip are very handy for observing, since you don't have to hold a flashlight in your other hand or mouth to make notes. Orion sells one called Lite-Write for $6 (www.telescope.com).

So don't let another winter go by in front of the wrong tube — turn off the TV and grab your trusty scope or binoculars. With a little cold-weather preparation on your part, the sky can be a friend for all seasons. ■

Maggie McKee is an associate editor at Astronomy.

Starsplitter Telescopes
Quality Focused on the Customer!

Starsplitter II
15"- 40"
Compacts
8"-15"

We offer the largest selection of Newtonian telescopes on the market today!

Please send $2.00 for a catalog. Online catalog at www.starsplitter.com

Starsplitter Tube
8"-10"
APO - Eater
8" f/7.6

Starsplitter Telescopes
3228 Rikkard Drive
Thousand Oaks, CA 91362
805-492-0489 Phone & Fax
www.starsplitter.com

STARLAB
Portable Planetarium

Learning Technologies, Inc.
40 Cameron Avenue • Somerville, MA 02144
Tel: 800-537-8703 • Fax: 617-628-8606
E-mail: starlab@starlab.com • www.starlab.com

THE OBSERVATORY

The Most Complete Telescope Store in Texas

TELESCOPES • MICROSCOPES • BINOCULARS

In the field set-up & instruction with every Astronomical Telescope purchase.

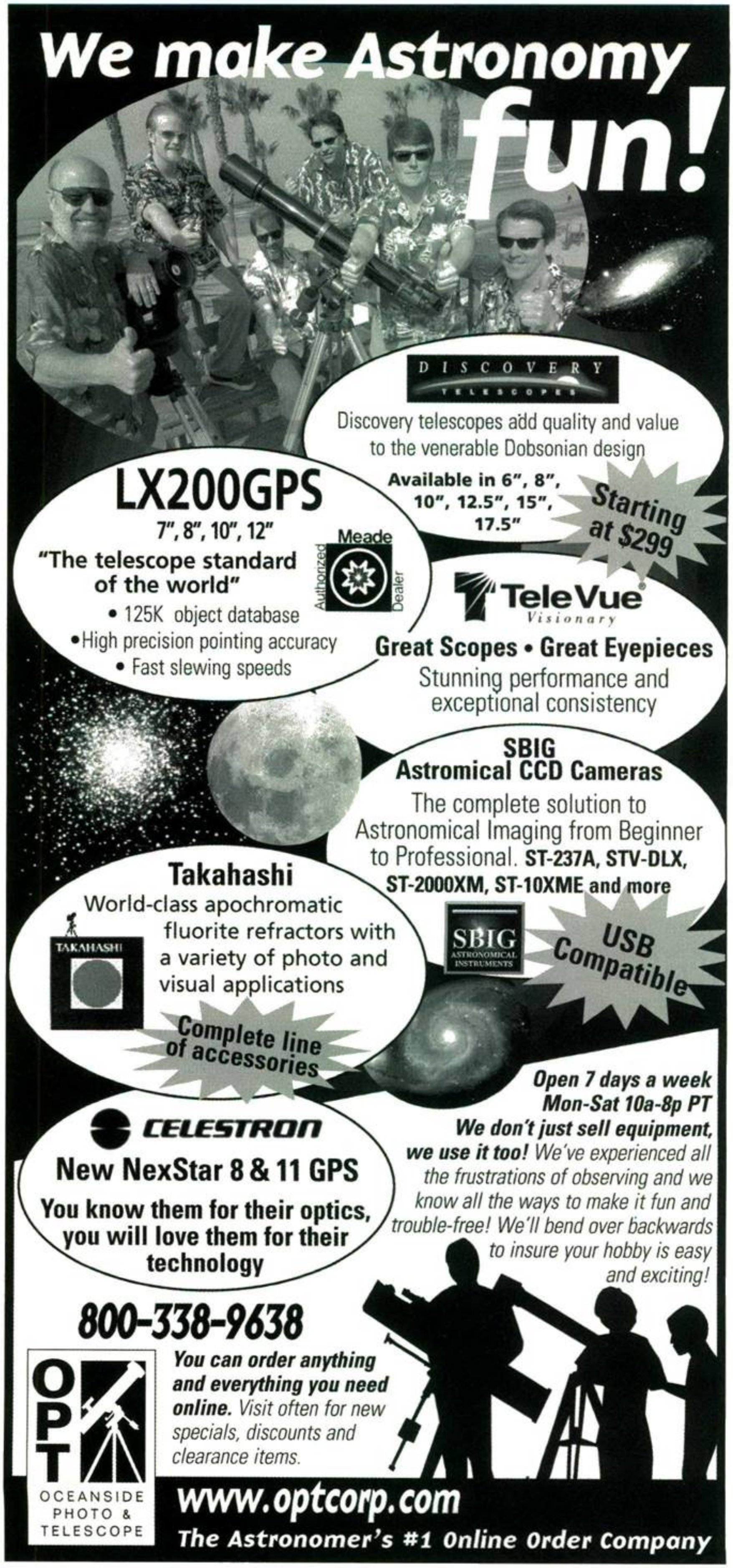
Astronomical Telescopes • Spotting Scopes
Binoculars & Giant Binoculars • Sky Charts
Atlases, Books • Computer Controlled
Telescopes • Astronomy Software

Celestron, Meade, Orion, Tele Vue®, Geochron, Canon, Swift, Spherical Concepts, Fujinon, Home-Dome by Technical Innovations

19009 Preston Rd., Suite 114 · Dallas, TX 75252
Located between Frankford & The George Bush Turnpike (Hwy. 190)
(972) 248-1450 · www.TheObservatoryInc.com

CAMERA BUG

TELESCOPES • BINOCULARS
ACCESSORIES • EYEPIECES
SPOTTING SCOPES
MAPS • BOOKS • SOFTWARE
Canon • Celestron • Meade • Minolta
Olympus • Orion • Pentax • TeleVue®
Kendrick • Rigel • Star Bound • Vixen
We Ship Almost Anywhere!
www.camerabug.com
Fax: (404) 873-3925
Orders Only: (800) 545-8509
(404) 873-4513
1799 Briarcliff Rd. • Atlanta, GA 30306



We make Astronomy fun!

DISCOVERY TELESCOPES

Discovery telescopes add quality and value to the venerable Dobsonian design

Available in 6", 8", 10", 12.5", 15", 17.5"

Starting at $299

LX200GPS
7", 8", 10", 12"
"The telescope standard of the world"
- 125K object database
- High precision pointing accuracy
- Fast slewing speeds

Meade Authorized Dealer

TeleVue Visionary

Great Scopes • Great Eyepieces
Stunning performance and exceptional consistency

SBIG
Astromical CCD Cameras
The complete solution to Astronomical Imaging from Beginner to Professional. **ST-237A, STV-DLX, ST-2000XM, ST-10XME and more**

SBIG ASTRONOMICAL INSTRUMENTS

USB Compatible

Takahashi
World-class apochromatic fluorite refractors with a variety of photo and visual applications

TAKAHASHI

Complete line of accessories

CELESTRON
New NexStar 8 & 11 GPS
You know them for their optics, you will love them for their technology

Open 7 days a week
Mon-Sat 10a-8p PT
We don't just sell equipment, we use it too! *We've experienced all the frustrations of observing and we know all the ways to make it fun and trouble-free! We'll bend over backwards to insure your hobby is easy and exciting!*

800-338-9638

You can order anything and everything you need online. *Visit often for new specials, discounts and clearance items.*

OPT
OCEANSIDE PHOTO & TELESCOPE

www.optcorp.com
The Astronomer's #1 Online Order Company

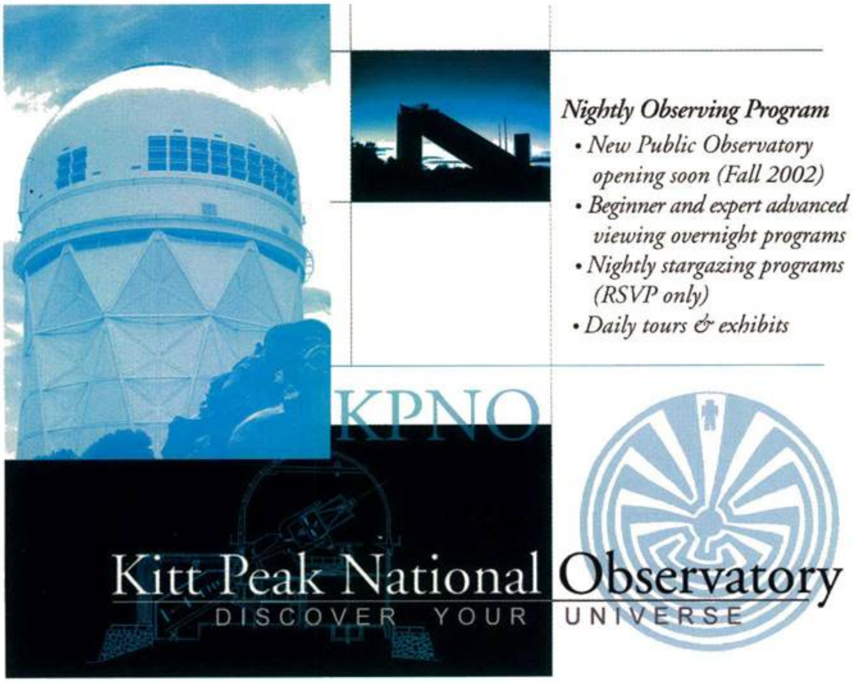
Swinburne Astronomy Online

- **Online Courses in Astronomy:**
  Designed for amateur astronomers, science educators, and anyone with a love of astronomy, Swinburne Astronomy Online is interactive astronomy education featuring custom-made CD-ROMs, newsgroup discussions and informed commentary on the latest astronomy headlines.
- **Programs:**
  We offer Master of Science in Astronomy and Graduate Diploma of Science in Astronomy programs, individual unit enrollment and a six-week short course, all online and accessible worldwide.

SWIN BUR NE
CENTRE FOR ASTROPHYSICS AND SUPERCOMPUTING

Further information: Swinburne Astronomy Online www.astronomy.swin.edu.au
Contact: Dr. Sarah Maddison, astro@swin.edu.au
Mail Box 31, Swinburne University of Technology,
PO Box 218, Hawthorn VIC 3122 Australia Fax: +61 3 9214 8797

33525



Nightly Observing Program
- *New Public Observatory opening soon (Fall 2002)*
- *Beginner and expert advanced viewing overnight programs*
- *Nightly stargazing programs (RSVP only)*
- *Daily tours & exhibits*

KPNO
Kitt Peak National Observatory
DISCOVER YOUR UNIVERSE

Project RedStar.™
ARE WE ALONE IN THE UNIVERSE?
THE QUESTION OF THE AGES!!
INCONTROVERTIBLE HARD EVIDENCE DOES EXIST!
DO YOU KNOW WHERE?

CALL 1-800-257-2672 or 1-877-257-2672
www.projectredstar.com or www.theredstarfiles.com

PROJECT REDSTAR.™

Astroshops.com
Your one-stop shop for telescopes & astronomy-related products

Green Laser Pointer
points out the stars
www.betapointer.com
phone 800.546.2382

Andromeda Software
Since 1985
Astronomy and Science CD-ROMs for IBM & Mac
Complete Online Catalog!
andromedasoftware.com
Secure Online Ordering

EfstonScience
The Science & Astronomy SuperStore

Canada's largest selection of telescopes, optics and accessories available and in stock!

ONLY AT EFSTONSCIENCE!
"...sets a new standard for an instrument in this price range."
—Terence Dickinson

ALL MAJOR BRANDS INCLUDING
MEADE APD
CELESTRON
TELEVUE
USED EQUIPMENT
TRADE-INS
EXPERT ADVICE

Serving Observing Since 1970

VISIT the SuperStore,
CALL for a **free** catalog
or **SHOP ONLINE** at
www·telescopes·ca
888-777-5255 3350 Dufferin Street
Toronto, Ontario, CANADA

Into the Ever-Stranger Cosmos

The deeper astronomers look, the stranger the universe becomes.

by Christopher Conselice

Not long ago the universe was a simple place. At the turn of the twentieth century no galaxies existed, no quasars, and no black holes. Only a backdrop of twinkling points and fuzzy nebulae littered the sky, and the universe was thought to be merely our solar system and its sun, planets, asteroids, and comets, floating in a lonely void of distant stars.

Anyone with even a casual knowledge of astronomy knows that the astronomical zoo has increased so explosively that we now know of hundreds of types of objects inhabiting the cosmos. But does that mean that the universe is a complicated place? Not as much as you might think. Most of the hundreds of types of celestial citizens are related to each other and can be woven together in the current tapestry of the universe. Understanding these objects, their origin and evolution, is the focus of much of modern astronomy. Astronomers know enough about the pieces from their studies that we can assemble a tour of the most significant elements that go into the solar system, the galaxy, and the universe at large.

The Whirlpool Galaxy (M51), a moderate-sized spiral, is ringed with bursts of star formation and giant clouds of ionized gas (pink knots) surrounding its center. NASA/STScI

The Big and Bold

The largest structures in the universe, galaxy clusters, hold thousands of galaxies together in their gravitational grip like a swarm of bees around a common center of mass. Recognized in the 18th century by William Herschel and Charles Messier — and then thought to be clumps of nebulae — galaxy clusters offer astronomers lots of information about the early universe. A single galaxy cluster can contain objects with individual sizes and masses greater than 1,000 times that of the Milky Way. Most of the galaxies in clusters, however, are low-mass objects with dark and mysterious backgrounds; astronomers don't yet understand how they came to be. Galaxy clusters contain all manner of galaxies, but the densest clusters are the hosts to galaxies that contain the oldest stars. Astronomers know of galaxy clusters about half way back to the origin of the universe, roughly eight billion years ago. Although they see plentiful galaxies before that time, no convincing evidence for galaxies congregating into clusters exists for the earliest clusters.

Clusters are important to astronomers not only because they host galaxies, but also because they contain large amounts of matter. They act as great laboratories, allowing astronomers to see how the mass in galaxies interacts with that in others. They also contain an extensive intracluster medium of gas and dust, including hot gas that appears vividly in new Chandra x-ray images of the cluster Hydra A, for example. Remarkably, galaxy clusters contain enough mass that they can be used as gravitational lenses, bending the light from distant galaxies that lie exactly behind them, and forming secondary images.

Not to be outdone by those who study galaxy clusters is the legion of astronomers who study individual galaxies themselves. While many galaxies exist in clusters, most are found in smaller groups of a few objects, as with the Milky Way's membership in a little cloud of galaxies termed the Local Group. The Local Group holds at least 39 galaxies in a sphere measuring roughly 10 million light-years across. Aside from the Milky Way, the predominant members of the Local Group are the Andromeda Galaxy (M31) and the Pinwheel Galaxy (M33) in Triangulum. As he viewed these and other galaxies in the 1920s, Edwin Hubble found that the most common galaxies are spirals, like M31 and M33, or ellipticals, enormous spherical balls of stars, gas, and dust.

But many other types of galaxies exist. Among many usual types of galaxies, so-called active galaxies are now recognized as an important class. Active galaxies are highly energetic critters with giant black holes in their centers, going through periods of grazing in which matter falls into the black hole and also gets flung outward at hyper velocities, forcing the galaxies to glow with a kind of galactic flu. Another particularly amazing type is the class of starburst galaxies, objects that are undergoing extreme periods of producing new suns. The most common type of galaxy, at least in the nearby universe, is the dwarf. Dwarfs are small, faint, low-mass systems that are likely the most important galaxies in the universe because they were probably the first galaxies to form.

The best place to start galactic touring is with the brightest galaxies, thousands of which are available for viewing in backyard telescopes. In any good, dark evening sky, dozens of bright examples are visible — particularly in the spring and the autumn. Elliptical galaxies are among the easiest to view by amateurs because they have high surface brightnesses; their round or elliptical glows stand up well to applying magnification. Ellipticals are composed of old stars and contain little evidence of dust, young stars, or hydrogen gas. Most of the stars in ellipticals are older than eight billion years. Ellipticals are most commonly found in clusters, and typically have masses several hundred times that of the Milky Way.

Spiral galaxies are certainly the most easily recognized type. Our own galaxy is a spiral, as are the Andromeda Galaxy and the Pinwheel. Most spiral galaxies, including the Milky Way, have features such as bars and rings — the Milky Way is classified as a barred spiral. These bars and rings form by dynamical effects such as interactions with other galaxies and are often associated with regions of star formation. The spiral arms in these galax-

Left: A deep composite infrared and visible light image from the Hubble Space Telescope shows numerous protogalaxies. NASA/STScI
Below: The galaxy cluster Hydra A glows in x-rays as recorded by the Chandra Observatory. NASA/CXC/SAO
Right: Spiral galaxy Dwingeloo 1 lies obscured by dust. INT

ies contain large amounts of young stars and significant clouds of dust and gas. The young, blue stars within spiral arms give these features their distinctive appearance. Spirals also usually have a bright central area known as a bulge, which has a smooth glow similar to elliptical galaxies. Most astronomers now believe that the bulges of spiral, as well as elliptical, galaxies probably formed from the mergers of many smaller galaxies.

The Disturbed, Small, and Meek

Not all galaxies are so graceful and well-behaved as spirals and ellipticals. Starburst galaxies, the objects undergoing episodes of high-powered star formation, have properties that are very unusual. The blast of star formation takes place when gas clouds inside these galaxies collide, get compressed, and subsequently make stars. Solving the riddle of how these gas clouds collide is one of the major topics in extragalactic astronomy.

Several methods might be the culprits in producing starburst galaxies. One is through interactions with other galaxies. When two galaxies collide, as with the Antennae (NGC 4038–9) in Corvus, the gas in the two galaxies compresses, which gets enough matter together to make new stars. Astronomers studying galaxies like the Antennae have been infused with a new spirit of excitement as they are now seeing extremely distant galaxies that appear to be undergoing ancient starbursts in the same way. Starburst galaxies in the nearby universe might be the best analogs, then, to the brightest galaxies that existed in the early universe.

The active galaxies, those powered by black holes, also offer great opportunities for astronomers hoping to decipher how galaxies work. This class includes many specialized types of galaxies, including BL Lacertae objects, quasars, and Seyfert galaxies. The primary difference between the different types of active galaxies seems to be geometric — the angle from which we view them, and also how bright the central part of the galaxy is. They all work basically the same way, with material falling into the black hole, which, in turn, accretes gas from the galaxy. This produces great amounts of light and other radiation streaming out from the galaxy's center, so much so that the central portion of a quasar can be several hundred times brighter than that of a normal galaxy.

The third major type of galaxy, dwarfs, constitutes the most plentiful type of galaxy in the nearby universe. Dwarf galaxies outnumber their larger counterparts by at least a factor of ten but are factors of 100 to 1,000 smaller and less massive than normal elliptical and spiral galaxies. Within the category of dwarfs, there are two basic types — dwarf ellipticals and dwarf irregulars. Dwarf irregulars are tiny galaxies undergoing miniature bursts of star formation. They are fundamentally different from starbursts and spiral galaxies only in their scales. These galaxies generally don't contain spiral arms as their mass is too small to sustain this kind of dynamic.

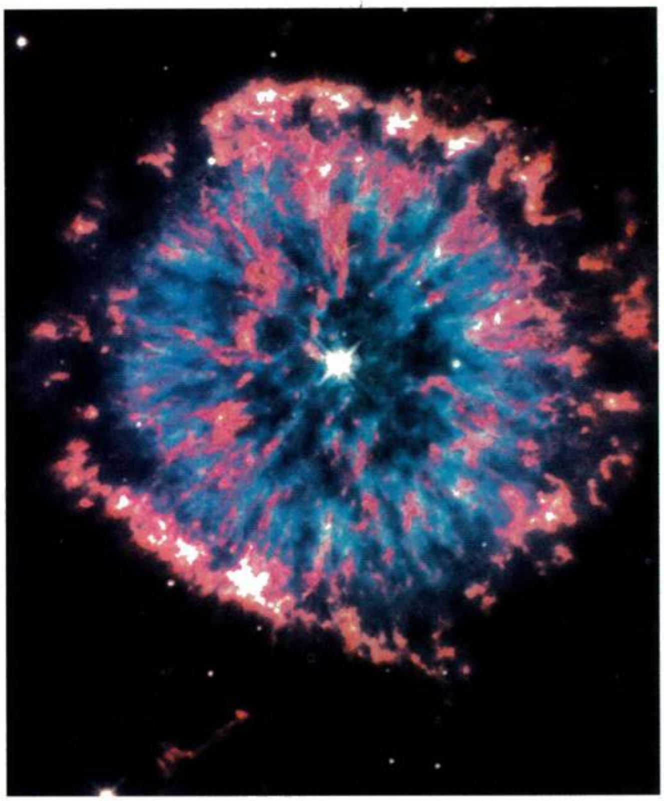
Dwarf ellipticals are the most common type of small galaxy and generally form in dense areas such as galaxy clusters. They contain mostly old stars, just as the giant ellipticals do, but are much fainter than normal elliptical galaxies. Current research on dwarf ellipticals suggests these objects formed through several mechanisms. In the future, understanding exactly how this most common type of galaxy came to be will be critical to unlocking the secrets of how all galaxies formed and evolved.

Inside the Galaxies

What about the objects inside galaxies? They contain numerous kinds of objects, including stars, an interstellar medium of gas and dust, planets, and — at least in our own galaxy — life. Stars come in many different types, just as galaxies do. Most stars are burning hydrogen in their cores, including all the stars we see in the night sky. These stars all have various brightnesses and colors which depend on their masses and ages.

There are always exceptions, but generally, massive, young stars are bright and blue while older, low-mass stars are redder. There's more to the story, however, as astronomers now know that very faint stars with low masses exist. These dwarf stars,

Left: Stephan's Quintet reveals interactions between members of a small galaxy group. NASA/STScI
Below: A burst of star formation (pinkish ring) has occurred in the galaxy NGC 4314 over the past five million years. NASA/STScI
Right: Planetary nebula NGC 6751. NASA/STScI

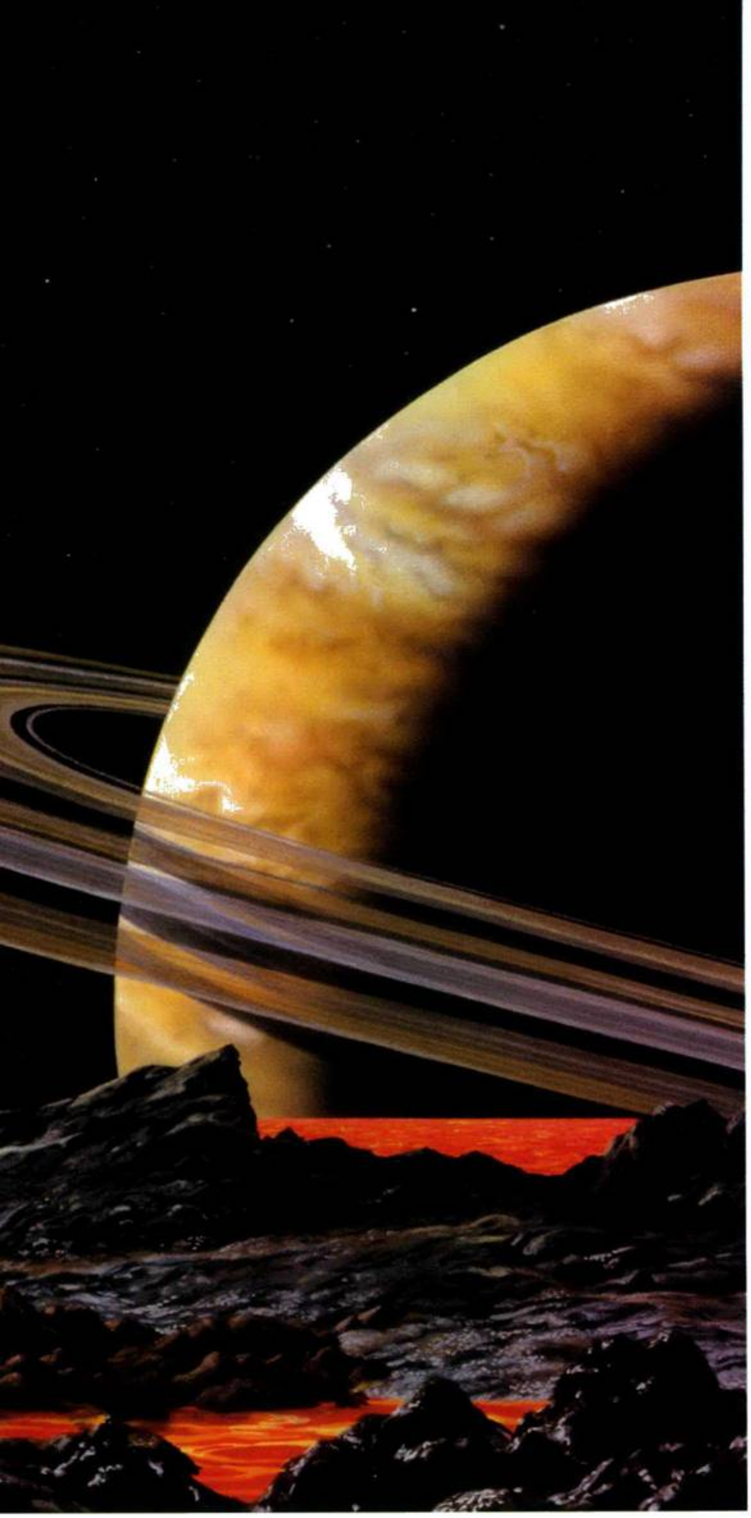


either brown or white, have masses of only 10 percent up to 1.4 times that of the sun.

In terms of producing exotic objects, few events top the deaths of stars. Three basic scenarios unfold when a star ends its life. If it is very massive, roughly more than eight times the mass of the sun, it explodes catastrophically in a supernova and the stellar remnant becomes either a black hole or a neutron star. Of these massive stars, those with the highest mass become black holes, the lower mass ones neutron stars. A neutron star is the result of a star's atoms being compressed enough to overcome the forces between the nuclei of atoms. The result is that the nuclei are pressed into a virtually solid object; if these neutron stars start to rotate, they release pulses of energy and we call them pulsars.

The third scenario, which is the eventual fate of lower mass stars like the sun, is to lose the outer parts of their structure and become white dwarfs. The visually appealing stage of this process results in a glowing shell of gas termed a planetary nebula. White dwarfs are very faint, hot objects with temperatures of 10,000 K and intrinsic brightnesses 10,000 times fainter than the sun; they are sized similarly to Earth. The most famous white dwarf, and the first discovered, is the companion star to Sirius, called Sirius B, discovered in 1862.

What about planets and other objects that orbit stars? Astronomers have now catalogued more than 100 extrasolar planets. Some of these orbit a common star, meaning that other solar systems beyond ours are known to exist. Many of these planets are very massive, however, several times heavier



More than 100 extrasolar planets are now known — greater than 10 times as many planets in our solar system. The planet orbiting 47 Ursae Majoris, a jovian-like world, is typical of the large bodies found thus far. Soon astronomers will also have the technical capability to discover earthlike worlds orbiting other stars. Lynette Cook

than Jupiter, the most massive planet in our system. The orbits of these planets appear to be very different than those of our solar system, too — many have very eccentric orbits, rather than the nearly circular orbits of our home planets. Astronomers don't yet know much about these extrasolar planets. They know that one planet circling the star HD 209458 has an atmosphere, having detected it by means of sodium absorption.

What astronomers know about planets comes almost entirely from our own solar system. We have nine planets here but also a large number of bodies orbiting the sun. The nearest of these are asteroids, which are principally found between Mars and Jupiter and have very small sizes and masses. The largest asteroid, Ceres, weighs in at only 0.02 percent of Earth. A range of asteroids exists, most consisting of some combination of silicates and metals such as nickel and iron. At least one, 243 Ida, is known to have its own satellite, Dactyl, similar to the way planets have moons. Asteroids exist throughout the solar system; they were probably among the first clumps of stuff to form in our neighborhood and could be very similar to planetesimals, which later accreted into the much larger planets.

The solar system doesn't stop there. Numerous comets and Kuiper Belt objects also float through the near-cosmos. Comets are well known to astronomers and non-astronomers alike, with their blazing tails glowing as they approach the sun. Comets are essentially dirty snowballs, with rock, ice, and gas frozen into a nucleus that orbits the sun in periods of a few years to several hundreds of thousands of years. Most comets sublimate away after a billion years, but new comets originating from the Oort Cloud on the distant horizon of the solar system replenish the supply.

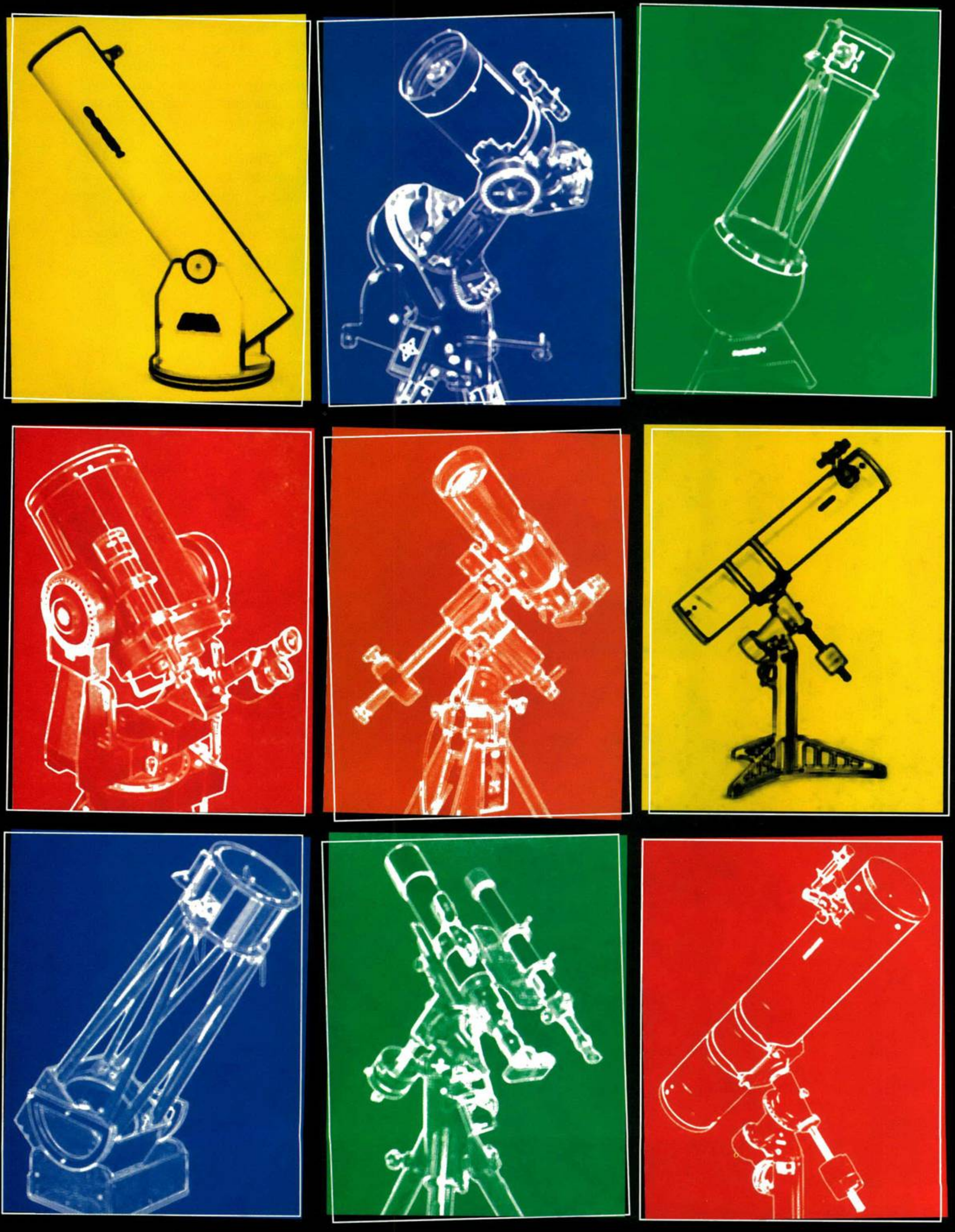
The Kuiper Belt objects are a separate breed. These objects orbit lazily beyond Pluto. Astronomers now know of more than 400 Kuiper Belt members and believe that tens of thousands may exist. Studying these objects will no doubt help to solve mysteries of the origin and evolution of the solar system, as they may be composed of pristine material from the earliest days of its formation.

Remaining Mysteries

What else does the universe hold? Is anything out there that we can't observe? The answer is undoubtedly yes. All the objects described thus far emit or reflect visible light. But this diversity represents only a small fraction of the matter in the universe. At least 99 percent of matter in the cosmos exists in nonstellar form. It is called dark matter, and its nature is anyone's guess. Several features about dark matter are known. It appears to be attached to galaxies and whatever it is, astronomers generally agree it is cold — the particles that make up dark matter are not moving very fast. Using this information, astronomers can make computer simulations that reproduce the structure of the universe, leading them to further believe that dark matter is cold.

Very recently, astronomers hypothesized that a significant amount of so-called dark energy exists, and that it is pushing — accelerating — the expansion of the universe. Astronomers now believe that the dark energy is acting as a force and driving the acceleration. We have little knowledge of dark energy and dark matter and how they might relate to astronomical objects, known and unknown, but every astronomer admits there's still a great deal to discover. The universe probably contains many types of objects far more exotic than those we currently know about. The next time you're out under the stars, gazing at some galaxy or nebula with your scope, remember that it's only a matter of time until the universe will look very different to us than it does today.

Christopher Conselice is an astronomer at the California Institute of Technology in Pasadena. This is his first article for Explore the Universe.



Best in Class

Looking to purchase a new scope? Let Astronomy *make the decision easy with our guide to 50 top telescopes.*

by Phil Harrington

One of the toughest decisions an amateur astronomer faces is which telescope to purchase. It's a personal question, one that can't be answered by anyone other than you. Many ingredients must be added to the decisional mix, including the types of celestial objects you find most interesting, where you'll use the telescope, where you'll store it, and, of course, how the scope fits into your budget.

Today's astronomers use one of four basic telescope designs: refractors, Newtonian reflectors, or two hybrids — the Schmidt-Cassegrain and the Maksutov-Cassegrain. Amateur astronomers have been known to defend their choice(s) in scope design with great fervor — much like sports fans argue in favor of their preferred teams. But all telescopes have their strong and weak points, and no single design is best for everyone.

Which instrument is best for you? To help answer this very important question, I have selected 50 favorite telescopes: the "Nifty Fifty." These have been divided into several different categories to help show which perform better than others on selected targets or for selected consumers. Categories include beginner, childrens, grab-and-go, deep-sky, planet-watching, and astrophotography. And please note that the telescopes listed within each category are listed alphabetically, so their order should not be interpreted as a comparative rating.

Selecting the Nifty Fifty does not mean that I consider other instruments unworthy. Amateur astronomers can choose among hundreds of fine instruments sold commercially. In limiting the list to 50, though, I have no doubt left out some meritorious instruments. So if you see an 8-inch telescope manufactured by a certain company listed, but you think to yourself, "Gee, that's kind of large for me; I'd probably prefer the 6-inch version of the same scope," then by all means, don't be afraid to downsize (or upsize). Odds are good that the two scopes share many of the same qualities.

Another important point to consider while browsing the Nifty Fifty: Just because a particular telescope is highlighted under one category doesn't mean that it's not suitable for others. In fact, many of the telescopes listed here easily fit into more than one category. For instance, I own an 18-inch reflector. On this list it falls under the "Deep Sky" heading. But on nights of steady seeing, my scope produces absolutely phenomenal views of the planets.

Regardless of the type of telescope you're searching for, the top priority should always be optical quality. Choose the wrong scope and you could find yourself beset with all manner of optical defects — blurry images, haloes, unresolvable fainter obects. Not much else matters if the optics disappoint. Then again, the finest optics can't overcome second-rate mechanics. A good mounting is critical, since it must be strong enough to steadily support the telescope's weight. If it's not, even the best telescopes will serve up little more than celestial Jell-O. Finally, consider what accessories come with the instrument — eyepieces and finder scopes are particularly critical if this is your first telescope.

Okay, now that the ground rules are set, let's take a look at the Nifty Fifty.

Beginner's Telescopes

Make/model	Aperture (inches)	Focal ratio	Type of telescope	Mounting type	Total weight (pounds)	Included accessories	Typical street price
Celestron C102-HD	4	9.8	Achromatic refractor	German equatorial on tripod	36	20mm Plössl eyepiece, 6x30 finder	$450
Discovery DHQ 6	6	5 or 8	Newtonian reflector	Dobsonian	32 or 34	25mm and 10mm Plössl eyepieces, 6x30 finder, Adjustable balancing plates	$340
Konusuper-Motor 120	4.7	8.3	Achromatic refractor	German equatorial on tripod	62	6x30 finder, 90° diagonal, 1.25" and 1.7" Plössl eyepieces, Moon filter	$540
Meade AR-5 5" LXD55	5	9	Achromatic refractor	German equatorial (Fully automated) on tripod	49	26mm Super Plössl eyepiece, 8x50 finder, Go-to computer drive, Illuminated polar alignment finder	$700
Novosibirsk Instruments TAL-150P8	6	8	Newtonian reflector	German equatorial on pedestal	88	25mm Plössl eyepiece, 15mm Kellner eyepiece, 2x Barlow lens, 8x50 finder, Six glass color filters, Clock drive, Sun projection screen, Hardwood storage case	$850
Orion Telescopes SkyView Deluxe 6	6	5	Newtonian reflector	German equatorial on tripod	39	25mm and 9mm Plössl eyepieces, 6x30 finder, Moon filter	$430
Orion Telescopes SkyQuest XT-6	6	8	Newtonian reflector	Dobsonian	37	25mm and 10mm Plössl eyepieces, 6x30 finder, Eyepiece rack	$350
Orion Telescopes StarMax 127	5	12.1	Maksutov	German equatorial on tripod	37	25mm Plössl eyepiece, 90° diagonal, 6x26 finder, Travel case	$570
Stargazer Steve 6 (kit)	6	8	Newtonian reflector	Dobsonian	24	17 mm Plössl eyepiece, Rigel QuikFinder, All components needed for assembly, Assembly manual and video	$380

Children's Telescopes

Edmund AstroScan	4.12	4.2	Newtonian reflector	Ball	13	28mm RKE eyepiece, Open Sight Target Finder, Aluminum Table-Top Base	$300
Orion Telescopes SkyQuest XT4.5	4.5	8	Newtonian reflector	Dobsonian	17.5	25mm and 10mm Plössl eyepieces, 6x26 finder, Eyepiece rack	$200
Stargazer Steve 4.25 Kit	4.25	10	Newtonian reflector	Dobsonian	16	12mm Kellner eyepiece, Target sight, All components needed for assembly, Assembly manual and video	$230
Stargazer Steve Sgr-4	4.25	7.1	Newtonian reflector	Altitude-azimuth on tripod	13	17mm Plössl eyepiece, Rigel QuikFinder	$310
Swift Instruments Model 864	4.5	8	Newtonian reflector	German equatorial on tripod	20	25mm Kellner eyepiece, 6x30 finder	$450

Grab-and-Go Telescopes

Borg 76SWII	3	6.6	Achromatic refractor	Altitude-azimuth on tripod	10	2" focuser	$810

Beginner Scopes

A good beginner's telescope should be simple in design, with an adequate collection of accessories to get the new stargazer off and running. At a minimum, this means one or two eyepieces, a finder of some sort, a decent mounting, and a clear set of instructions.

Celestron C102-HD Celestron's 4-inch f/9.8 C102-HD refractor is a basic, well-designed instrument that is light enough for easy transport, but large enough to give a great view of the moon, planets, and an assortment of bright deep-sky objects.

Discovery DHQ 6 Discovery's 6-inch f/8 DHQ 6 Newtonian combines good optical quality with sound, basic mechanics, and enough accessories to give years of viewing enjoyment.

Konusuper-Motor 120 The 4.7-inch f/8.3 refractor is a basic, well-designed instrument that is light enough to be easily carried down a flight of stairs, but large enough to give a great view of the moon, planets, and many bright deep-sky objects.

Meade 5-inch LXD55 The 5-inch f/9 Meade LXD55 refractor is an excellent performer for beginners in terms of optical quality, computerized mounting, accessories, and overall quality.

Novosibirsk Instruments TAL-150P8 From Russia with love comes the TAL-150P8, a heavy-duty 6-inch f/8 Newtonian reflector on a sturdy German equatorial mount and with just about every accessory a beginner could need.

Orion Telescopes SkyView Deluxe 6 Orion Telescope's 6-inch f/5 SkyView Deluxe 6 delivers optics that are consistently good, while its tripod-mounted German equatorial mount offers sturdy, lightweight support.

Orion Telescopes SkyQuest XT6 The 6-inch f/8 SkyQuest XT6 Newtonian offers a nice compromise of aperture and portability — two important attributes of a beginner's telescope. The telescope's parabolic mirror combined with the included 10 and 25mm Plössl eyepieces are perfect for "newbies."

Orion StarMax 127 If portability is an important consideration, then a telescope like the 5-inch f/12.1 Orion StarMax 127 is a good choice. Standard accessories include a padded carrying case, a star diagonal, a finder scope, a 25mm Plössl eyepiece, and an equatorial mount.

Stargazer Steve 6 Kit The 6-inch f/8 Stargazer Steve kit includes optics, focuser, tube, mount, finder, eyepiece, complete instructions, and all the pre-cut wood you'll need to make a complete Newtonian in an afternoon.

Children's Scopes

So often, parents will give their child a telescope for his or her birthday or other holiday, only to find that its poor quality renders it useless. Costing just a little more than many of these junky department store scopes, each of the instruments below is a great jumping-off point for a lifelong interest in astronomy.

Edmund AstroScan Immediately recognizable for its unique design, the 4.12-inch f/4.2 AstroScan Newtonian is lightweight and easy to aim, focus, and store when not in use. The telescope comes with an eyepiece and is supported with a three-point tabletop base that may also be attached to a camera tripod.

Orion Telescopes SkyQuest XT4.5 The 4.5-inch f/8 XT4.5 Newtonian resembles its larger siblings, but scaled down to meet the needs and carrying ability of a child. Still, its aperture is large enough to take young astronomers to many sky objects.

Stargazer Steve 4.25 Kit Like the 6-inch kit mentioned previously, the Stargazer Steve 4.25 Kit includes everything needed to build a complete Newtonian in an afternoon, along with great video instructions. All you need to do is put the kit together and finish the wood with paint or stain.

Stargazer Steve Sgr-4 Although it costs more than the kit, the Sgr-4 produces sharp, clear images of the moon, planets, and brighter deep-sky objects with its parabolic mirror. This Newtonian comes with a 17mm eyepiece, a finder, and a varnished hardwood altazimuth mount.

Swift Instruments Model 864 A 4.5-inch f/8 Newtonian reflector,

Make/model	Aperture (inches)	Focal ratio	Type of telescope	Mounting type	Total weight (pounds)	Included accessories	Typical street price
Celestron C102-AZ	4	5	Achromatic refractor	Altitude-azimuth on tripod	17.5	20mm Plössl eyepiece 45° diagonal, 6x30 finder	$400
Celestron NexStar 5	5	10	Schmidt-Cassegrain	Computerized Go-to on tripod	17.5	25mm Plössl eyepiece Starpointer finder Go-to computer drive	$1,150
Meade ETX-90EC	3.5	13.8	Maksutov-Cassegrain	Fork (fully automated)	8	26mm Super Plössl eyepiece, 90° diagonal	$500
Meade ETX-70AT	2.8	5	Achromatic refractor	Fork (fully automated) on tripod	7	25mm and 9mm MA eyepieces, 90° diagonal, Go-to computer drive	$350
Orion Telescopes ShortTube 80 EQ	3.1	5	Achromatic refractor	German equatorial	16	25mm and 10mm Explorer II eyepieces, 6x26 finder	$290
Questar Standard 3.5	3.5	14.4	Maksutov	Fork equatorial	7	24mm and 16mm Brandon eyepieces, 4x & 6x finder, Built-in 2x Barlow lens, Clock drive, Travel case	$4,050
Stellarvue AT1010	3.1	6	Achromatic refractor	Sold separately	5 (without a mount)	2" focuser, Red dot finder, Eyepieces sold separately	$450
Tele Vue Pronto	2.8	6.8	Semi-apochromatic refractor	Sold separately	6 (without a mount)	20mm Plössl eyepiece, 2" focuser, Travel case	$775

Planetary Telescopes

Make/model	Aperture (inches)	Focal ratio	Type of telescope	Mounting type	Total weight (pounds)	Included accessories	Typical street price
Astro-Physics 130mm f/6 StarFire EDFS	5.1	6	Apochromatic refractor	Sold separately	15 (without a mount)	Giant focuser with 1.25" and 2" adapters, Carrying case	$4,740
DGM Optics OA-5.5	5.5	10.1	Off-axis Newtonian reflector	Dobsonian	48	2" focuser	$1,650
Intes Micro Alter M715	7	15	Maksutov	Sold separately	15 (without a mount)	2" diagonal, 2" focuser, Finder bracket, Carrying case	$2,300
Starmaster ELT 11	11	4.5	Newtonian reflector	Dobsonian	64	2" focuser, Rigel QuikFinder, Light shroud	$2,900
Takahashi CN-212	8.3	3.9 (Newt) 12.4 (Cas)	Newtonian/ Cassegrain reflector	German equatorial on tripod	43	2" focuser, 7x50 finder, Motor drives, 24mm LE ocular eyepiece, 90° diagonal, 3 collimating tubes, Collimating scope, Photo corrector	$10,600
Vixen GP-102M	4	9.8	Achromatic refractor	German equatorial	46	20mm Lanthanum eyepiece, 90° diagonal, 6x30 finder	$1,350
Vixen GP FL-102S	4	9	Apochromatic refractor	German equatorial	37	20mm Lanthanum eyepiece, 90° diagonal, 6x30 finder	$2,900

Deep-sky Telescopes

Make/model	Aperture (inches)	Focal ratio	Type of telescope	Mounting type	Total weight (pounds)	Included accessories	Typical street price
Astro-Physics 105mm f/6 Traveler EDFS	4.1	6	Apochromatic refractor	Sold separately	9 (without a mount)	Giant focuser with 1.25" and 2" adapters, Carrying case	$3,480
Discovery Premium DHQ 10	10	6	Newtonian reflector	Dobsonian	81	25mm and 10mm Plössl eyepieces, 8x50 finder or Telrad, 2" focuser, Adjustable altitude bearings	$950

the Swift Model 864 is noteworthy for its excellent optical quality. Equipped with a 6x30 finder scope, two Plössl eyepieces, and a tripod-mounted German equatorial mount, the Swift 864 is small enough for children ages 12 and above to lift and carry easily.

Grab-and-Go Scopes

There is a growing appeal among all stargazers to own a telescope that is small enough to carry with one hand, but still has enough "oomph" to show brighter sky objects. Known as "grab-and-go" telescopes, they are perfect for astronomers who — to find darker skies or hunt exotic targets — like to take their shows on the road.

Borg 76SWII The 3-inch f/6.6 Borg 76SWII refractor offers a modular design that breaks down into several small individual pieces, all packaged well for easy travel. This scope is ideal for eclipse chasers.

Celestron C102-AZ The biggest appeal of Celestron's 4-inch f/5 C102-AZ refractor is its wide field of view, which produces some spectacular views of large star clusters like the Pleiades, and Milky Way star clouds. The C102-AZ comes with a sturdy altazimuth mounting and aluminum tripod.

Celestron NexStar 5 Celestron's 5-inch f/10 NexStar 5 Schmidt-Cassegrain combines a nice optical tube atop a computerized mount that steers the telescope right to any of 18,000 objects.

Meade ETX-90EC One of the most popular telescopes ever introduced, Meade's 3.5-inch f/13.8 ETX-90EC Maksutov combines maximum portability, outstanding images, state-of-the-art electronics, and an exceptional price.

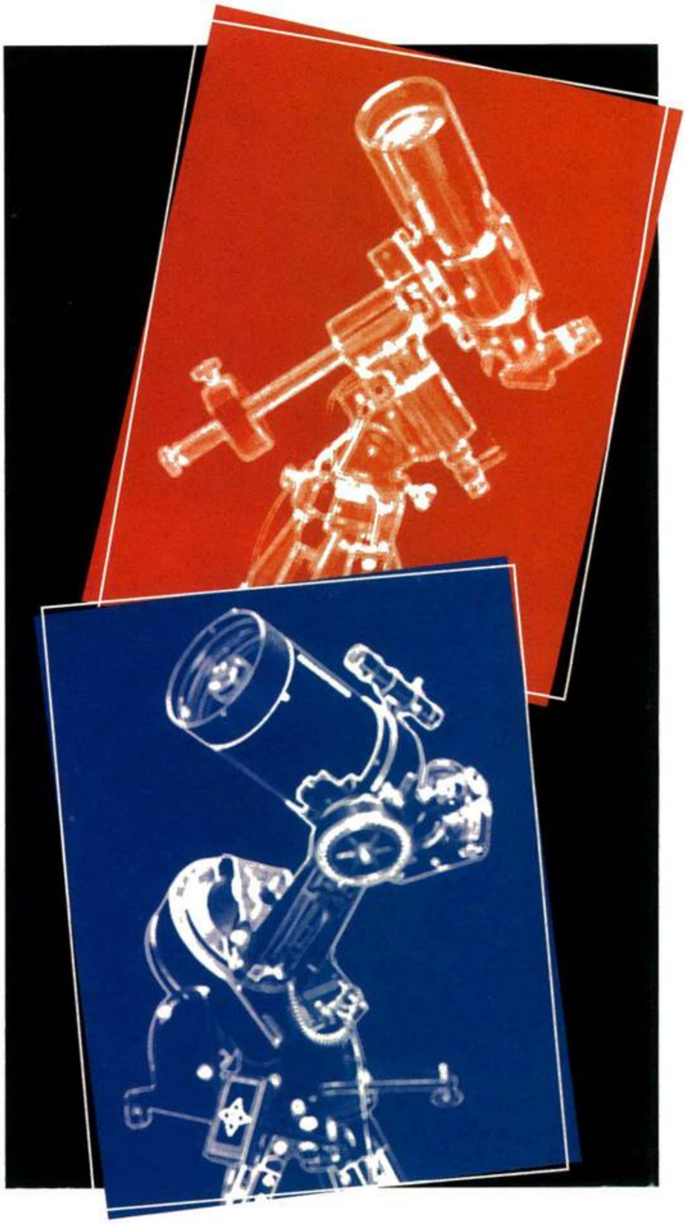
Meade ETX-70AT Here is a great grab-and-go telescope that is also perfect for children of all ages. Like the ETX-90EC Maksutov, the wide-field Meade 2.8-inch f/5 ETX-70AT refractor comes on a computerized mount designed to pilot the telescope across the sky.

Orion Telescopes ShortTube 80 When first introduced in the 1990s, Orion's little 3.1-inch f/5 ShortTube 80 refractor invented the genre of grab-and-go telescopes for those on a tight budget. A decade later, the low-priced ST80 still produces great low-power views of Milky Way star clouds.

Questar Standard 3.5 Introduced in the 1950s, the coveted Questar 3.5, an exquisite 3.5-inch f/14.4 Maksutov, exemplifies the pinnacle of telescope manufacturing — both optically and mechanically. And its carrying case and integral fork-equatorial mount means that you can take this superb scope with you wherever you go.

Stellarvue AT1010 The excellent optical quality of the 3.1-inch f/6 Stellarvue AT1010 refractor, combined with its portability, sturdy mechanics, and reasonable price, proves that this instrument is a terrific bargain.

Tele Vue Pronto Although the 2.8-inch f/6.8 Tele Vue Pronto is great for wide-field views, its excellent optical quality lets observers really push the telescope to its limits, affording good views of the planets as well.



Planetary Scopes

In order to give good views of the planets, a telescope must have top-notch optics housed in a package that maximizes image contrast. While many instruments fall short of these needs, the following are more than capable of delivering what they promise.

Astro-Physics 130mm f/6 StarFire EDFS This 5.1-inch f/6 apochromatic refractor is an exceptional instrument, both optically and mechanically. Images are breathtakingly sharp and show great contrast with no sign of optical imperfections.

DGM Optics OA-5.5 Based around a unique, off-axis reflector design, the 5.5-inch f/10.1 DGM OA-5.5 gives refractor-like views of the planets for a fraction of the cost of an apochromat.

Intes Micro Alter M715 A new offering from Intes Micro in Russia, the 7-inch f/15 Alter M715 Maksutov features a small central obstruction and enhanced aluminizing to maximize planetary image contrast. Accessories such as a finder, eyepieces, and mounting are all sold separately.

Make/model	Aperture (inches)	Focal ratio	Type of telescope	Mounting type	Total weight (pounds)	Included accessories	Typical street price
Discovery Truss Design 12.5	12.5	5	Newtonian reflector	Dobsonian	80	8x50 finder or Telrad, 2" focuser, Light shroud, Tube-carrying case	$2,000
JMI NGT-18	18	4.5	Newtonian reflector	Split-ring equatorial	245	25mm Plössl eyepiece, 9x50 finder, 2" focuser, Digital setting circles, Dual-axis clock drive	$12,900
Mag 1 PortaBall 12.5	12.5	5	Newtonian reflector	Ball	62	Rigel Quikfinder, 2" focuser	$3,400
Meade Starfinder 12.5	12.5	4.8	Newtonian reflector	Dobsonian	96	26mm Super Plössl eyepiece	$800
Obsession 18	18	4.5	Newtonian reflector	Dobsonian	107	2" focuser	$4,700
Orion Telescopes SkyQuest XT10	10	5	Newtonian reflector	Dobsonian	58	25mm and 9mm Plössl eyepieces, 2" focuser, 8x50 finder Moon filter, Eyepiece rack	$650
Starmaster Truss 18	18	4.3	Newtonian reflector	Dobsonian	132	2" focuser, Telrad finder, Light shroud	$5,500
Starsplitter II 18	18	4.5	Newtonian reflector	Dobsonian	102	2" focuser, Telrad finder	$4,900
Tele Vue NP-101	4	5.4	Apochromatic refractor	Sold separately	10 (without a mount)	2" diagonal, 2" focuser, Travel case	$3,400

Astrophotographic Telescopes

Astro-Physics 155mm f/7 StarFire EDF	6.1	7	Apochromatic refractor	Sold separately	27 (without a mount)	4" focuser with 1.25" and 2" adapters, Carrying case, 4" field flattener	$8,880
Celestron NexStar 11GPS	11	10	Schmidt-Cassegrain	Fork equatorial (fully automated) on tripod	91	40mm Plössl eyepiece, 90° diagonal, 9x50 finder, Go-to computer drive	$3,000
Celestron CM-1400	14	11	Schmidt-Cassegrain	Equatorial on tripod	164	26mm Plössl eyepiece, 2" 90° diagonal, 9x50 finder	$5,300
Meade LX10 Deluxe	8	10	Schmidt-Cassegrain	Fork mount with equatorial wedge on tripod	49	26mm Super Plössl eyepiece, 90° diagonal, 6x30 finder, Clock drive	$1,150
Meade LX200GPS	8	10	Schmidt-Cassegrain	Fork equatorial (fully automated) on tripod	73	26mm Super Plössl eyepiece, 90° diagonal, 8x50 finder, Go-to computer drive	$2,500
Meade LX200SC Schmidt Camera	12	2.2	Schmidt camera	Fork equatorial (fully automated), permanent pier	585	7" f/9 ED refractor photo-guide telescope, 8x50 finder, Go-to computer drive	$25,400
Takahashi Epsilon 250	10	3.4	Hyperbolic flatfield astrograph reflector	German equatorial mount on tripod	126	4" focuser with 1.25" and 2" adapters, 11x70 finder, Motor drives	$17,000
Takahashi FSQ-106	4.2	5	Apochromatic refractor	German equatorial mount on tripod	49	4" focuser with 1.25" adapter 7x50 finder, Motor drives	$7,750
Vixen GP-DX R200SS	7.9	4	Newtonian reflector	German equatorial on tripod	65	Giant focuser with 1.25" and 2" adapters, 7x50 finder, Motor drives	$2,150

Starmaster ELT 11 Not many Dobsonian-style Newtonians could qualify as good planetary scopes, but Starmaster's 11-inch f/5.4 reflector is a noteworthy exception. Part of the secret is the telescope's optics, from Carl Zambuto, a company renowned for its consistent excellence.

Takahashi CN-212 Takahashi makes many outstanding telescopes, but none stands out like the CN-212, a convertible 8.3-inch Newtonian-Cassegrain reflector. Because of its adaptability, this scope can handle both planetary and deep-sky observing equally well.

Vixen GP FL-102M Arguably the finest 4-inch achromatic refractor sold today, the f/9.8 Vixen GP-102M comes mounted on the acclaimed Great Polaris (GP) German equatorial mount and an aluminum tripod. The rack-and-pinion focuser takes 1.25-inch eyepieces, but will also accept 2-inch eyepieces with an optional adapter.

Vixen GP FL-102S The 4-inch f/9 Vixen GP FL-102S apochromatic refractor produces brilliant, tack-sharp images with excellent contrast. This quality coupled with Vixen's highly regarded Great Polaris mount makes this an exceptional instrument. It's available in the United States as the Orion VX102-FL GP refractor.

Deep-Sky Scopes

Deep-sky observers used to have a one-track mind. They fixated exclusively on aperture size, believing larger lenses were the only means to resolve their beloved faint objects. Now we know better. Sure, aperture is important, but so is optical quality. Sometimes a small telescope will show more than a large one, depending on which object you're viewing. The selections below offer a mix of both of these criteria.

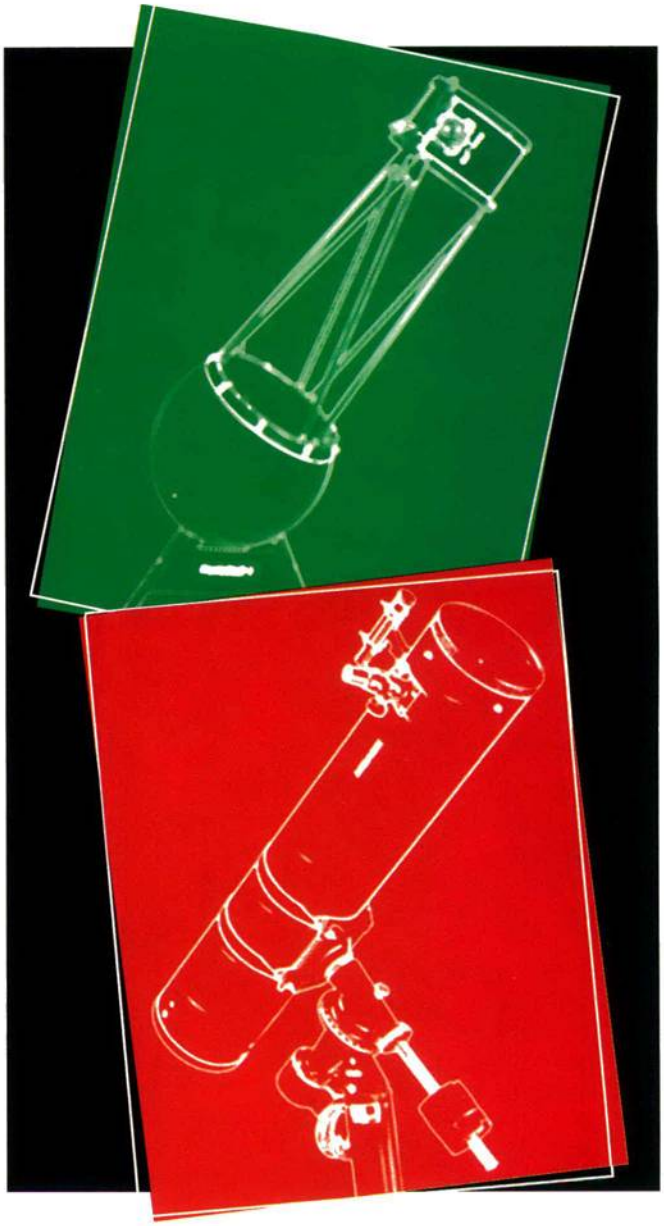
Astro-Physics 105mm f/6 Traveler EDFS This apochromatic refractor may only measure 4.1 inches in aperture, but the Astro-Physics Traveler's fantastic f/6 optical system delivers views of large deep-sky objects that are unparalleled through larger instruments with narrower fields.

Discovery Premium DHQ 10 Discovery's "premium" Dobsonian-mounted reflectors are a cut above their standard DHQ models mentioned earlier. With better accessories and a more finished appearance, the 10-inch f/6 Premium DHQ packs enough aperture to show thousands of deep-sky treasures, yet is small enough for easy transport.

Discovery Truss Design 12.5 Discovery Truss Design Dobsonians, such as their 12.5-inch f/5 model, offer the nomadic astronomer the added flexibility of breaking down the telescope for easier transport than the solid-tubed Premium DHQ's. Optical quality is equally good in both.

JMI NGT-18 One of the most sophisticated Newtonians on the market, the 18-inch f/4.5 JMI NGT-18 offers a huge aperture on an elegant clock-driven, split-ring equatorial mount. Standard features include a motorized 2-inch focuser and digital setting circles.

Mag 1 PortaBall 12.5 The 12.5-inch f/5 PortaBall Newtonian is a unique instrument, to say the least. Riding in a spherical base, the PortaBall uses highly regarded optics from Carl Zambuto to create a telescope that is perfect for deep-sky observing as well as planet watching.



Meade Starfinder 12.5 One of the best buys in the world of telescopes, Meade's 12.5-inch f/4.8 Starfinder reflector offers high-quality optics in a basic package at a great price. Owners may want to upgrade the focuser and finder.

Obsession 18 One of the finest open-tube Dobsonians, the Obsession 18 was the first high-quality reflector sold to quench the deep-sky observer's thirst for aperture. Workmanship, choice of components, and image quality are absolutely top notch. What else could a deep-sky observer want?

Orion Telescopes SkyQuest XT10 The 10-inch f/5 SkyQuest XT10 Newtonian is another deep-sky bargain, offering consumers a large aperture, excellent optical quality, and very good standard accessories at a remarkably low price.

Starmaster Truss 18 Starmaster has quickly earned a reputation for making some of the finest Newtonians around. The 18-inch

Telescope Companies

Astro-Physics, Inc.
11250 Forest Hills Road
Rockford, IL 61115
Phone: (815) 282-1513
Website: http://www.astro-physics.com

Borg (Oasis Borg)
Hutech Corporation
23505 Crenshaw Blvd. #225
Torrance, CA 90505
Phone: (310) 325-5511
Website: http://www.sciencecenter.net/hutech

Celestron
2835 Columbia Street
Torrance, CA 90503
Phone: (310) 328-9560
Website: http://www.celestron.com

DGM Optics
P.O. Box 120
Westminster, MA 01473
Phone: (978) 874-2985
Website: http://www.erols.com/dgmoptics

Discovery Telescopes, Inc.
615 South Tremont Street
Oceanside, CA 92054
Phone: (877) 523-4400, (760) 967-6598
Website: http://www.discovery-telescopes.com

Edmund Scientific
60 Pearce Avenue
Tonawanda, NY 14150
Phone: (800) 728-6999, (716) 874-9091
Web site: http://www.scientificsonline.com

Intes Micro Co. Ltd.
Shvernika, 4, 117036
Moscow, Russia
Phone: +75095-126-9903
U.S. Importer:
Internet Telescope Exchange
3555 Singing Pines Road
Darby, MT 59829
Phone: (406) 821-1980
Website: http://www.burnettweb.com/ite

Jim's Mobile, Inc. (JMI)
810 Quail Street, Unit E
Lakewood, CO 80215
Phone: (800) 247-0304, (303) 233-5353
Website: http://www.jimsmobile.com

Konus
Via Mirandola
45-37026 Settimo di Pescantina
Verona, Italy
Phone: 39-045-676-7670
U.S. Office:
8359 N.W. 68th Street
Miami, FL 33166
Phone: (305) 592-5500
Website: http://www.konus.com

Mag 1 Instruments
16342 West Coachlight Drive
New Berlin, WI 53151
Phone: (262) 785-0926
Website: http://www.mag1instruments.com

Meade Instruments Corp.
6001 Oak Canyon
Irvine, CA 92618
Phone: (800) 626-3233, (949) 451-1450
Website: http://www.meade.com

Novosibirsk Instrument-Making Plant (TAL Instruments)
179/2 D. Kovalchuk St.
Novosibirsk, 630049, Russia
Phone: +7(383-2) 260-765, 254-542
Website: http://www.telescopes.ru
North American importer:
TALscopes
599 Norris Court
Kingston, ON, Canada K7P 2R9
Phone: (866) 384-4144
http://www.talscopes.com

Obsession Telescopes
P.O. Box 804W
Lake Mills, WI 53551
Phone: (920) 648-2328
Website: http://www.globaldialog.com/~obsessiontscp/OBHP.html

Orion Telescopes and Binoculars
P.O. Box 1815
Santa Cruz, CA 95061
Phone: (800) 447-1001
Website: http://www.telescope.com

Questar Corporation
6204 Ingham Road
New Hope, PA 18938
Phone: (215) 862-5277
Website: http://www.questar-corp.com

Stargazer Steve
1752 Rutherglen Crescent
Sudbury, ON P3A 2K3 Canada
Phone: (705) 566-1314
Website: http://stargazer.isys.ca

Starmaster Portable Telescopes
2160 Birch Road
Arcadia, KS 66711
Phone: (620) 638-4743
Website: http://www.starmastertelescopes.com

Starsplitter Telescopes
3228 Rikkard Drive
Thousand Oaks, CA 91362
Phone: (805) 492-0489
Website: http://www.starsplitter.com

Stellarvue
P.O. Box 7515
Auburn, CA 95604
Phone: (530) 823-7796
Web site: http://www.stellarvue.com

Swift Instruments, Inc.
952 Dorchester Avenue
Boston, MA 02125
Phone: (800) 446-1116
Website: http://www.swift-optics.com

Takahashi Seisakusho Ltd.
41-7 Oharacho
Itabashiku, Tokyo 174-0061 Japan
Product(s): Refractors, reflectors, mounts, eyepieces
U.S. Importer:
Texas Nautical Repair
3110 South Shepherd Drive
Houston, TX 77098
Phone: (713) 529-3551
Website: http://www.lsstnr.com

Tele Vue Optics, Inc.
32 Elkay Drive
Chester, NY 10918
Phone: (845) 469-4551
Website: http://www.televue.com

Vixen Optical Industries Ltd.
(A division of Tele Vue Optics, Inc.)
247 Hongo
Tokorozawa, Saitama 359-0022 Japan
Phone: (845) 469-8660
Website: http://www.VixenAmerica.com

f/4.3 Truss reflector features exquisite Zambuto optics in a detachable mirror cell for easier transport, as well as a 2-inch focuser, finder, and other accessories.

Starsplitter II 18 The 18-inch f/4.5 Starsplitter II reflector, like those from Obsession and Starmaster, packages a huge aperture into an easily transported design. No tools are needed to assemble the telescope, with all hardware held captive to ensure that nothing is lost in the dark of night.

Tele Vue NP-101 Like the Astro-Physics Traveler, Tele Vue's 4-inch f/5.4 apochromatic NP-101 refractor is perfect for wide-field views of large star clusters and galaxies. Outstanding optical and mechanical quality ensures the sharpest images.

Astrophotographic Scopes

With the growth of CCD technologies, more and more amateur astronomers are capturing images of the universe for all to see. The best pictures come from a combination of artistic skill, luck, and the right equipment. You're guaranteed at least the latter with any of the scopes below.

Astro-Physics 155mm f/7 StarFire EDF The 6.1-inch f/7 StarFire EDF refractor is designed expressly for photography. Its three-element objective lens combined with a field flattener lens in the rear of the optical tube assembly eliminates any hint of astigmatism and field curvature in photographs.

Celestron NexStar 11GPS Certainly one of the most sophisticated Schmidt-Cassegrains on the market, the NexStar 11GPS includes a worm-gear drive system with integrated periodic-error-correction for greater tracking accuracy. An equatorial wedge, available separately, is needed for long exposures.

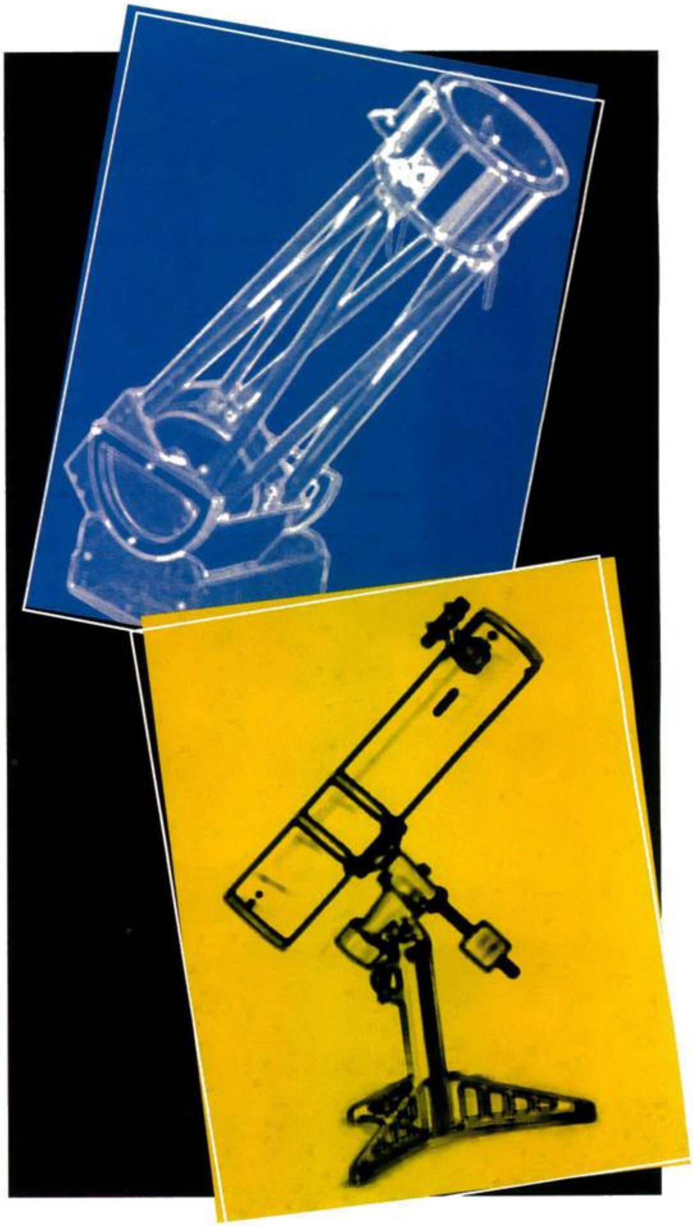
Celestron CM-1400 The 14-inch f/11 CM-1400 Schmidt-Cassegrain is truly an observatory-class instrument that can also be made transportable with as few as two people. Thanks to its stable German equatorial mount, the CM-1400's large aperture can produce spectacular photographic results.

Meade LX10 Deluxe Like the Celestar 8, the 8-inch f/10 LX10 Deluxe SCT lets new astrophotographers whet their appetites. Bonuses of the LX10 Deluxe include its worm-gear drive, its better 8x50 finderscope, and an electric declination motor.

Meade LX200GPS 8 The Meade LX200GPS Schmidt-Cassegrain includes a well-designed optical tube atop a computer-controlled fork mount. Like the Celestron NexStar scopes, the LX200GPS requires an equatorial wedge for long exposures.

Meade LX200SC Schmidt Camera The only amateur telescope designed solely for astrophotography, the 12-inch f/2.2 LX200SC Schmidt camera is for serious hobbyists who want to photograph extremely wide, flat fields at an amazingly fast photographic speed. Although this telescope cannot be used visually, the standard 7-inch photo-visual guidescope can.

Takahashi Epsilon 250 Although they can also be used visually, the hyperbolic optics and superb mechanics in the 10-inch f/3.4 Takahashi Epsilon 250 are designed specifically for deep-sky photography. The mount features a built-in polar-alignment scope and other amenities.



Takahashi FSQ-106 This 4.2-inch f/5 refractor includes a huge focuser that can be rotated a full 360° without shifting focus — making it much easier to look through a camera's viewfinder when aimed at odd angles. Image quality is second to none.

Vixen GP-DX R200SS The R200SS, a stubby 7.9-inch f/4 instrument on the acclaimed Vixen GP-DX equatorial mount, is perfect for wide-field astrophotography. The R200SS includes a 2-inch rack-and-pinion focuser that also features a built-in T-adapter for attaching cameras directly to the scope, a nice touch that eliminates the need for a separate camera mount.

Although this brings us to the end of our list, it by no means signifies the end of telescope possibilities for today's backyard stargazer. By narrowing down what you want to do with your telescope, assessing your budget, and doing a little research, you will indeed find a telescope perfect for you. ■

Phil Harrington, a frequent contributor, is the author of the newly updated Star Ware. *Visit his website at www.philharrington.net.*

because sometimes you don't have all the answers.

news • features • sky charts • forums • astroshops • photo gallery • astrokids

Astronomy.com

AC37939AD19

Join *Astronomy* Magazine in Alaska for a

Northern Lights Tour

March 1 – 9, 2003

Space is limited - don't delay!

Chase the colorful curtains of the aurora borealis through Alaska's interior with *Astronomy* Magazine. Along with catching one of the most spectacular views of the night sky, you will experience the magnificent vistas of a great, unspoiled wilderness.

Our experience begins in Chena Hot Springs, 60 miles from Fairbanks, and far from light pollution. The evening aurora should produce an impressive show as solar activity is expected to be high in March 2003. During the day, you can take advantage of a horse-drawn sleigh ride, a dog sled ride and a sunset snow-monkey ride to the top of the mountain. Or relax in the world-famous hot springs.

The adventure continues with four nights in Fairbanks at the Westmark Fairbanks Hotel. You can arrange to shop, downhill ski, attend the Ice Festival, or simply curl up with a good book.

The breathtaking scenery is guaranteed to put you on sensory overload. Whatever your choices for the daylight and evening hours, pack your warm clothes and join Astronomy editor, Rich Talcott on this watch for the magical northern lights in the heart of Alaska. See you there!

For more information
call Specialty Tours today at: 1-800-677-9412
(US only) or 727-796-7555
Visit: alspecialtytours.com
E-mail: markh@alspecialtytours.com

Astronomy

Alaskan aurora photograph by Mike O'Leary A38443ad

NO TOOLS!
$16 SHIPPED WORLDWIDE

Bob's Knobs
Easy Collimation for
Meade & Celestron SCT
Morrow Technical Services
6976 Kempton Rd.
Centerville IN 47330 USA
765-855-5109
www.bobsknobs.com

SURPLUS SHED℠
SURPLUS OPTICS AND ELECTRONICS
FREE CATALOG
Phone/fax/faxback TOLL FREE:
1-877-7SURPLUS • 610-926-9226
E-Mail: SURPLUSHED@aol.com
WWW: http://www.SurplusShed.com
407 U.S. Route 222, Blandon, PA 19510

Put a new *twist* on fine focusing!

The FeatherTouch SCT MicroFocuser
from Starlight Instruments

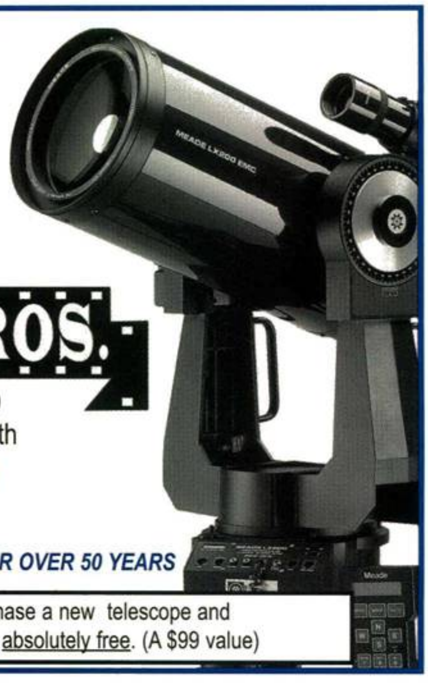
Fits Celestron
NexStar 11 GPS
NexStar 8 GPS
NexStar 8
Ultima 2000
And more...

Smooth focusing
Plus 10:1 fine focusing

Available at
STARIZONA
www.starizona.com * 520-292-5010

VISIT US AT:
Astronomy.com

We are one of the largest mail order dealers in the U.S. We carry all Meade and Celestron telescopes and accessories at discounted prices.



BERGER BROS.
209 Broadway (Route110)
Amityville, Long Island, Earth
800-262-4160
www.berger-bros.com

EXCELLENT REPUTATION AND SERVICE FOR OVER 50 YEARS

Mention this ad when you purchase a new telescope and get a Meade Electronic Eyepiece, absolutely free. (A $99 value)

WIDE-FIELD EYEPIECES
- 50° to 86°, sharp down to F/3.5
- Atmospheric Dispersion Correction (pat.)
- Perfect Mirror Achromatism (pat.)
- 4 or 5 element, no doublets (pat.)
- 3 to 30mm f.l., 8 to 30mm eye relief

Licensees invited. $5.00 royalty.

OFF-AXIS MIRRORS

6", 8", 10", 1:6, 1/20 wave, no central obstruction. Optical windows available.

AUGEN OPTICS
947 Parkside Lane
Lancaster, PA 17601 since 1980
Phone or FAX 717-295-4679
Toll Free 1-877-621-0994

ECLIPSE SHADES™

Safe Solar Viewers

Custom Imprinting Available!

ECLIPSE SHADES
SAFE FOR DIRECT SOLAR VIEWING

Eclipse Shades™ provide the ultimate in protection from harmful Solar Radiation. Lenses made of Optical Grade, Neutral Density 5 Mylar, filter out 100% of Ultra-Violet, 100% of Infra-Red, and 99.999% of Visible Light.

Quality Paper Eyewear & Specialty Optics

Rainbow Symphony, Inc.
6860 Canby Ave. #120, Reseda, CA 91335
1-800-821-5122 FAX (818) 708-8470
E-Mail: eclipse@rainbowsymphony.com
www.rainbowsymphony.com/soleclipse.html

Anyone can sell you a telescope.

We'll sell you the *right* telescope.

Authorized Meade Dealer

It takes more than a camera store clerk with a price list and a wild guess to help you pick the right telescope. It takes experience. It takes people who actually use the telescopes and accessories they sell. At ***astronomics,*** we have that experience. We've been selling telescopes for over 23 years. Some of us have been using them far longer than that. From the more than 100 different telescopes we carry, at prices from $99 to $28,000, we'll help you pick the scope that fits your needs *. . . and your budget.* Meade, Celestron, TeleVue, Takahashi, Questar, Vixen, and more – we have *all* the good stuff. No hard sell. No guesswork. Just honest advice . . . and a good price.

Call us toll-free at (800) 422-7876 or E-Mail us for our free Catalog XU. It has 8 pages of useful information on how to pick the right telescope, plus your discount prices on the 100 different telescope models and more than 1000 different accessories we carry . . . all at savings up to 50%. The call will only take a minute of your time . . . but it will be a minute very well spent.

astronomics

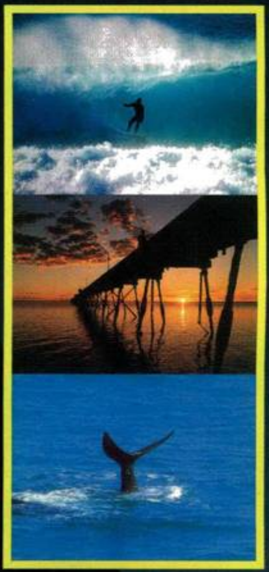
Our 24th year of friendly service, good advice, and money-saving prices.

680 SW 24th Avenue, Norman, OK 73069
(800) 422-7876 www.astronomics.com
FAX: (405) 447-3337 E-Mail: questions@astronomics.com
Visa, Mastercard, American Express, Discover
Phone hours: 10 to 5 CST Mon - Fri, 12 to 5 Sat. U. S. sales only.

Restocking fees apply to returns for credit and to merchandise returned in used or damaged condition.

Astronomy Magazine

Experience the **ECLIPSE** In the land down under!



PRETOUR TO CAIRNS/ GREAT BARRIER REEF
November 23 - November 28, 2002

ECLIPSE AUSTRALIA
November 26 - December 6, 2002

SPECIAL EXTENSION TRIP TO NEW ZEALAND
December 6 - December 11, 2002

Explore the land and sky of beautiful Australia. You'll travel through Sydney, Melbourne and other exotic places on a full but relaxed itinerary which includes observatories, star party, planetarium, classes on the Southern Skies, the Swinburne Center for Astrophysics & Supercomputing, sightseeing and of course, the CEDUNA ECLIPSE!

So journey to the continent you've always wanted to visit for an astronomical experience of a lifetime. Pre-tour and special extension trip also available. Call today for more information!

For more information call Specialty Tours
today at: 1-800-677-9412 (US only)
or 727-796-7555
Visit: www.a1specialtytours.com
E-mail: markh@a1specialtytours.com

A38444ad

AD INDEX

Analytical Scientific 93
Andromeda Software 71,93
Astrographics Publishing 3
Astronomics 92
Astronomy Book Club 35
Astronomy Calendars 64
Astronomy Magazine 99
Astronomy.com 90
Augen Optics 92
Berger Brothers Camera Video 91,93
Best Video Productions 71
Beta Electronics 71
Bob's Knobs 91
Cambridge University Press 19
Camcor, Inc 93
Camera Bug 70
Earth Treasures 65
Eclipse 2002 Tour to Australia 92
EfstonScience Inc 73,91
Focus Camera 18
Galatica 360 64
Khan Scope Centre 93
Kitt Peak National Observatory 71
Knollwood Books 65
Kowa Optimed Inc. 37
Learning Technologies, Inc. 36,64,70
Meade Instruments Corp 108
National Academy Press 36
New Mexico Skies 93
Northern Lights Tour 2002 91
Observatory Inc, The 70
Oceanside Photo & Telescope 70
Orion Telescopes & Binoculars 107
Owl Services 93
Princeton University Press 65
Questar Corporation 18
Rainbow Symphony 92
Rivers Camera Shop 93
Roger W Tuthill, Inc 93
SAC Imaging Systems 65
Scientifics 36
Scopetronix 37
Sky Watchers Inn 36
Software Bisque 2
Starsplitter Telescopes 70
Starstone Software Systems 93
Surplus Shed 91
Swinburne University of Technology 71
Talscopes.com 93
Wholesale Optics 18
Zarf Enterprises 93

Get a whole
new look!
Nikon binoculars.
Let the adventure begin!
Astroluxe XL
- All metal construction for durability
- Nikon's superior technology
- BaK4 high index prisms
- 100% Waterproof/Fogproof

model available 18x70

camcor.com
800-868-2462
www.camcor.com e-mail: sky@camcor.com
2273 South Church St. • Burlington, NC 27215 • Fax # 336-222-8011 • 336-228-0251

Nikon
A better look at your world®

25-year limited warranty included on all Nikon binoculars. ©2002 Nikon Inc.
www.nikonusa.com

Web Site Directory

ANALYTICAL SCIENTIFIC
asltd@analyticalsci.com
www.analyticalsci.com
Largest selection of Telescopes in TX. Meade, Celestron, Tele Vue. Science, Nature, educational items.

CAMERA CORNER
sky@camcor.com
www.camcor.com
Largest selection of Telescopes in the Southeast. Spotting Scopes, Binoculars, Maps, Books, Cameras.

NEW MEXICO ASTRONOMICAL
Telescope Specialists
www.nmastronomical.com
Before you buy, try our telescopes at night. Largest display of telescopes in NM. (505) 720-5666

Roger W. Tuthill, Inc.
sales@tuthillscopes.com
www.tuthillscopes.com
Retail sales of telescopes and accessories including our patented solar filters. Over 25 years experience!

ANDROMEDA SOFTWARE INC.
COMPLETE ONLINE CATALOG
andromedasoftware.com
Astronomy & Science
CD-ROMS for IBM & Mac
Since 1985

EFSTONSCIENCE
www.telescopes.ca
sales@telescopes.ca
The Science and Astronomy SuperStore
Canada's best prices and selection
Serving observing since 1970

OWL SERVICES
owl1@postoffice.ptd.net
www.owlservices.com
Special prices on KONUS telescopes - binoculars!
FREE # 1-888-OWL-WARE
10-5 EST M-F

STARSTONE SOFTWARE
info@starstonesoftware.com
starstonesoftware.com
Where Science Rocks!
Science software and screensavers for windows.

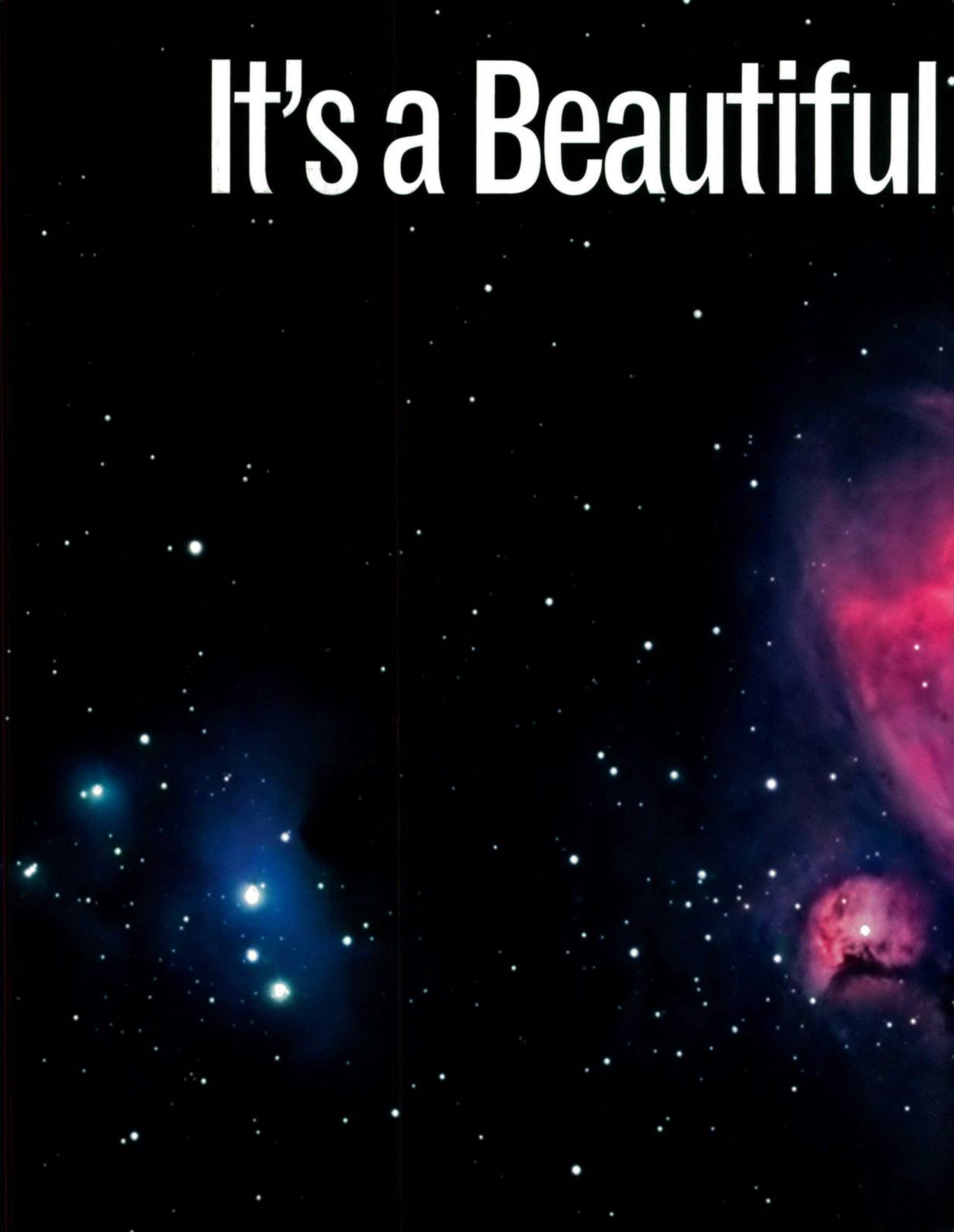
BERGER BROS.
CAMERA, VIDEO, DIGITAL
scopes@berger~bros.com
www.berger-bros.com
Over 50 years of sales and service at the best possible prices.

KHAN SCOPE CENTRE
khan@khanscope.com
www.khanscope.com
New, used. Free newsletter.
3243 Dufferin St.
Toronto, Ontario, Canada

RIVERS CAMERA SHOP
rivers@ttlc.net
riverscamera.com
Large inventory. Meade, Celestron, Televue, Thousand Oaks, Kendrik, Apogee, Canon, Pentax.

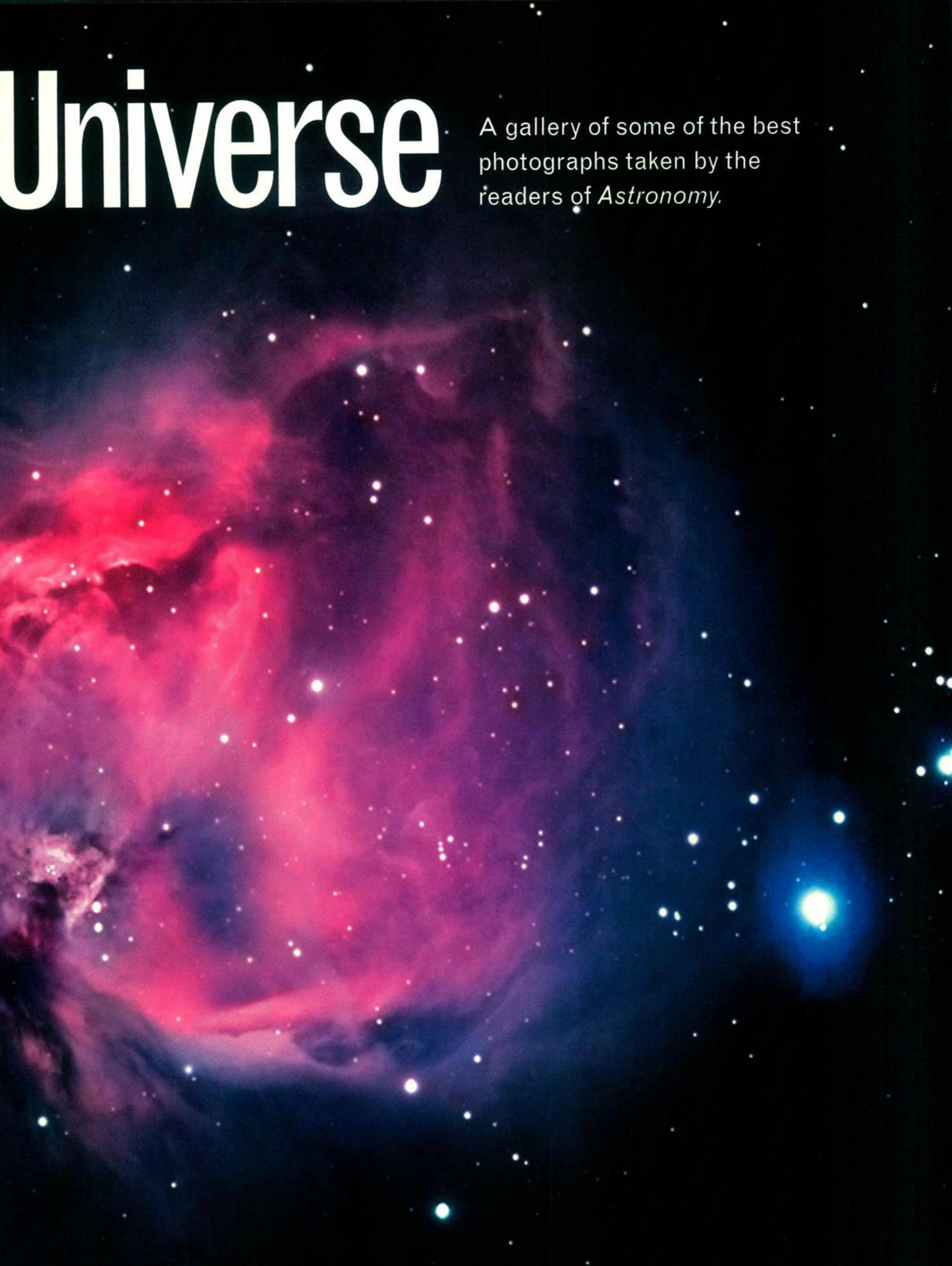
ZARF ENTERPRISES
COMPLETE ONLINE CATALOG
www.zarfenterprises.com
World's best digital camera adapters for Nikon CP & Sony digital cameras. Custom adapters available.

It's a Beautiful



Universe

A gallery of some of the best photographs taken by the readers of *Astronomy.*



Previous spread: M42, the Orion Nebula

MATHEW RUSSELL

(4-inch refractor at f/5, SBIG 10E CCD camera, composite exposure)

Right: Comet Ikeya-Zhang

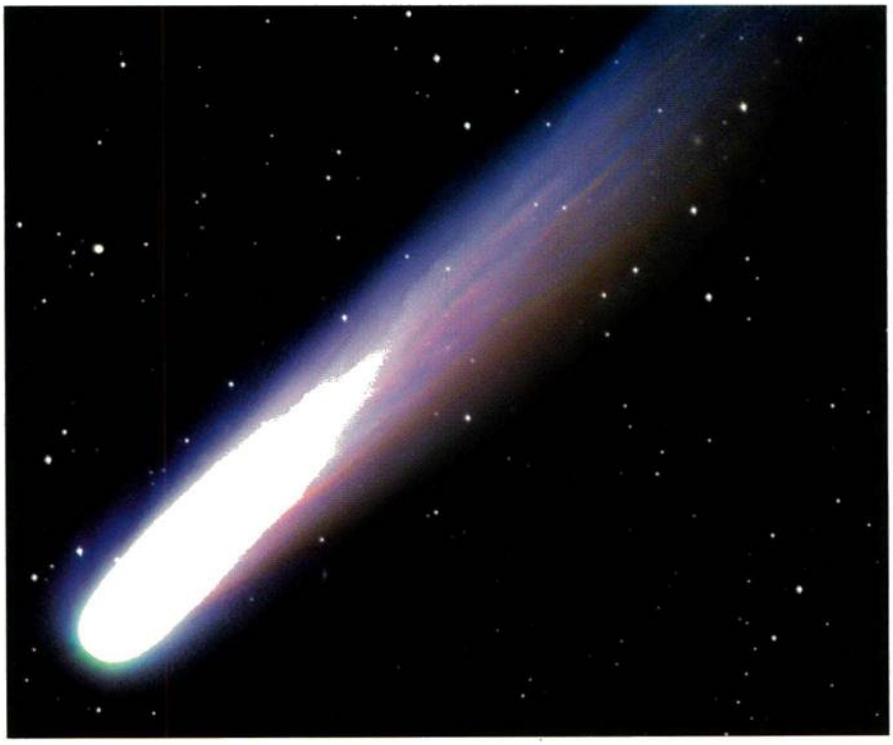
JACK NEWTON

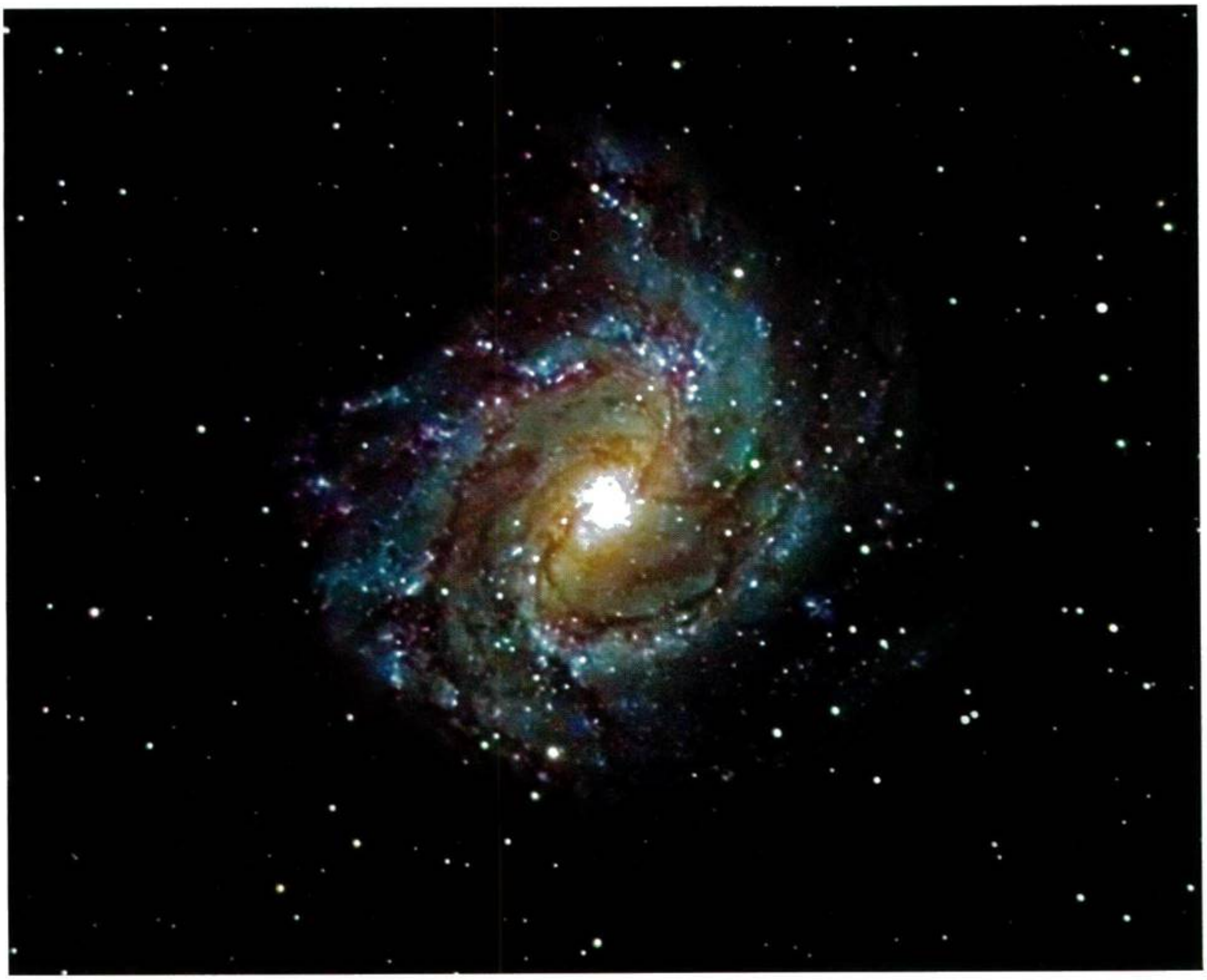
(7-inch apochromatic refractor at f/9 on a 16-inch SCT, Finger Lakes Dream Machine CCD camera, composite exposure taken March 14, 2002)

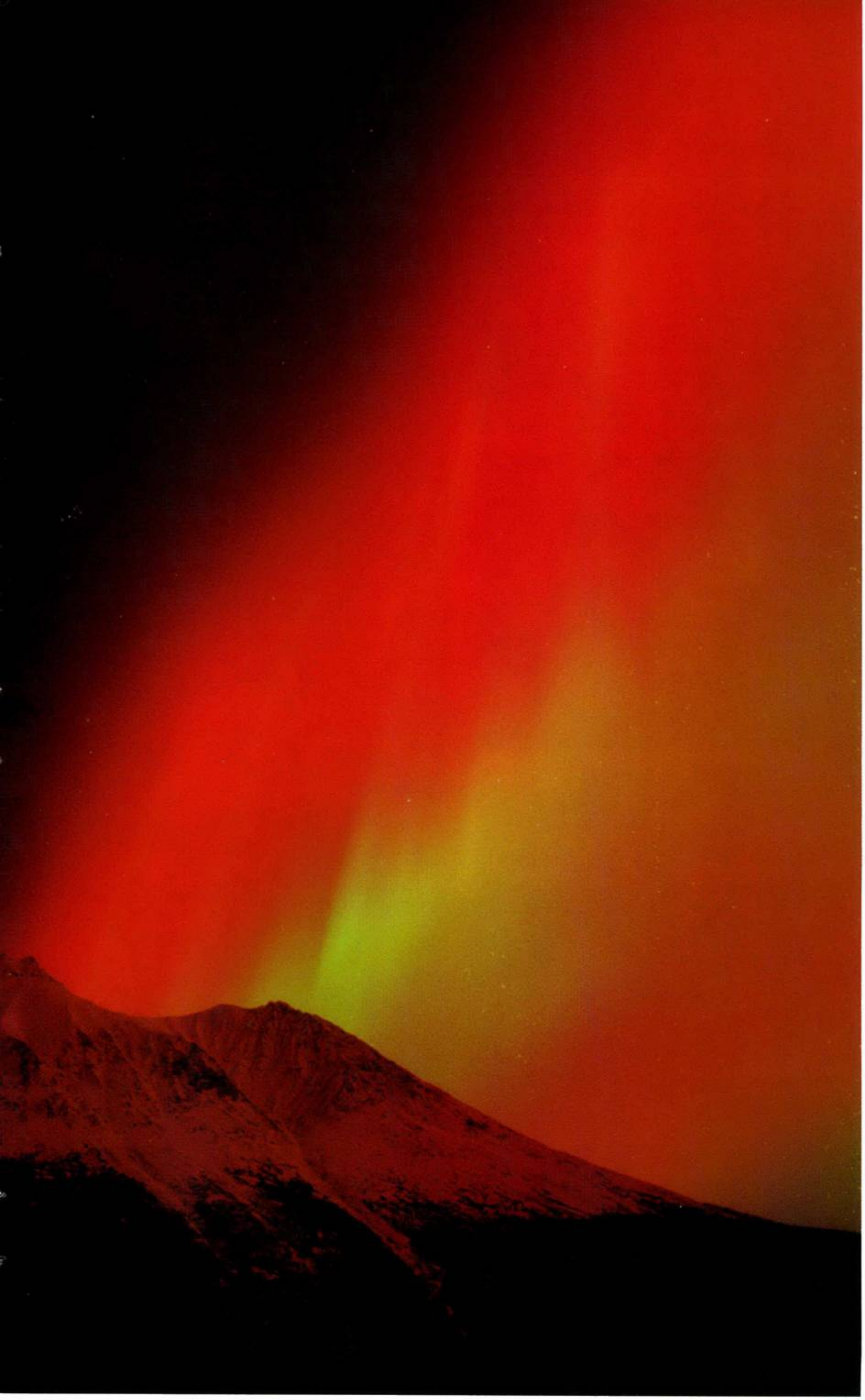
Below: M83, Southern Pinwheel Galaxy

RICHARD JACOBS

(9.25-inch SCT at f/10, SBIG ST-8E CCD camera, composite exposure)



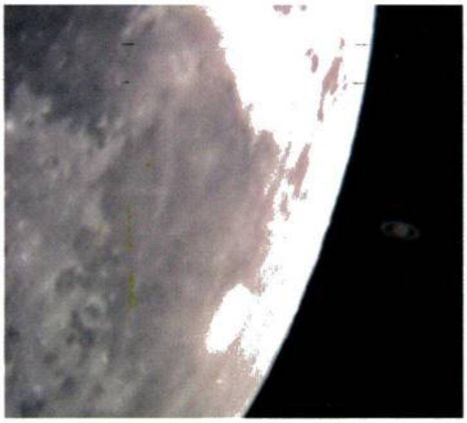




Aurora over Alaska

MICHAEL KLENSCH

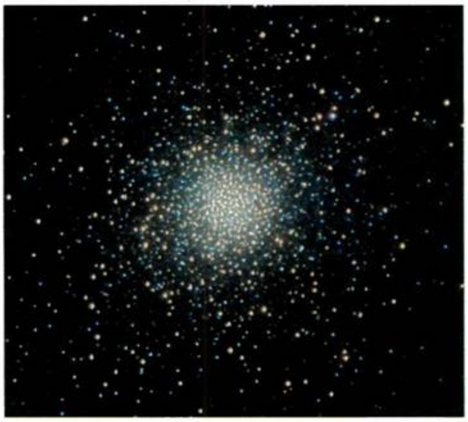
(24mm lens at f/2.8, Fuji 400 Superia film, 15-second exposure taken November 5, 2001 near the Alaska/Canada border)



Occultation of Saturn and the moon

JASON WARE

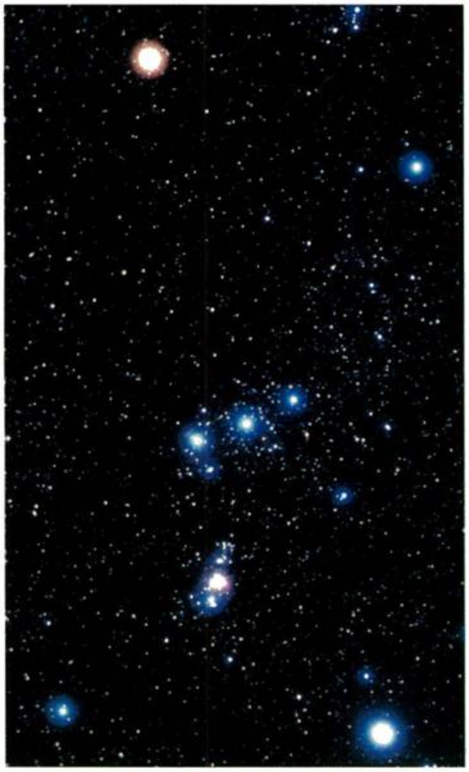
(16-inch SCT, Sony digital camera held to a 40mm eyepiece)



Globular Cluster M5

CHRIS SCHUR

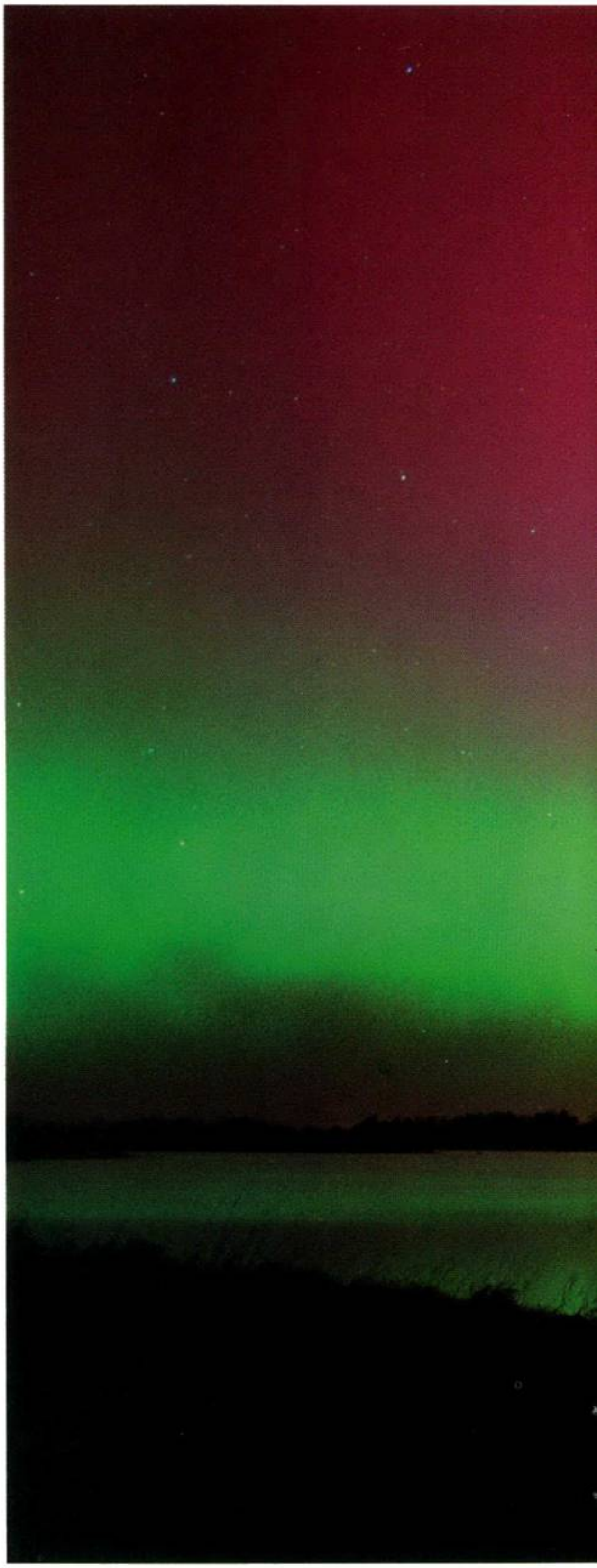
(12.5-inch reflector at f/5, SBIG ST-7E CCD camera, composite exopsure)

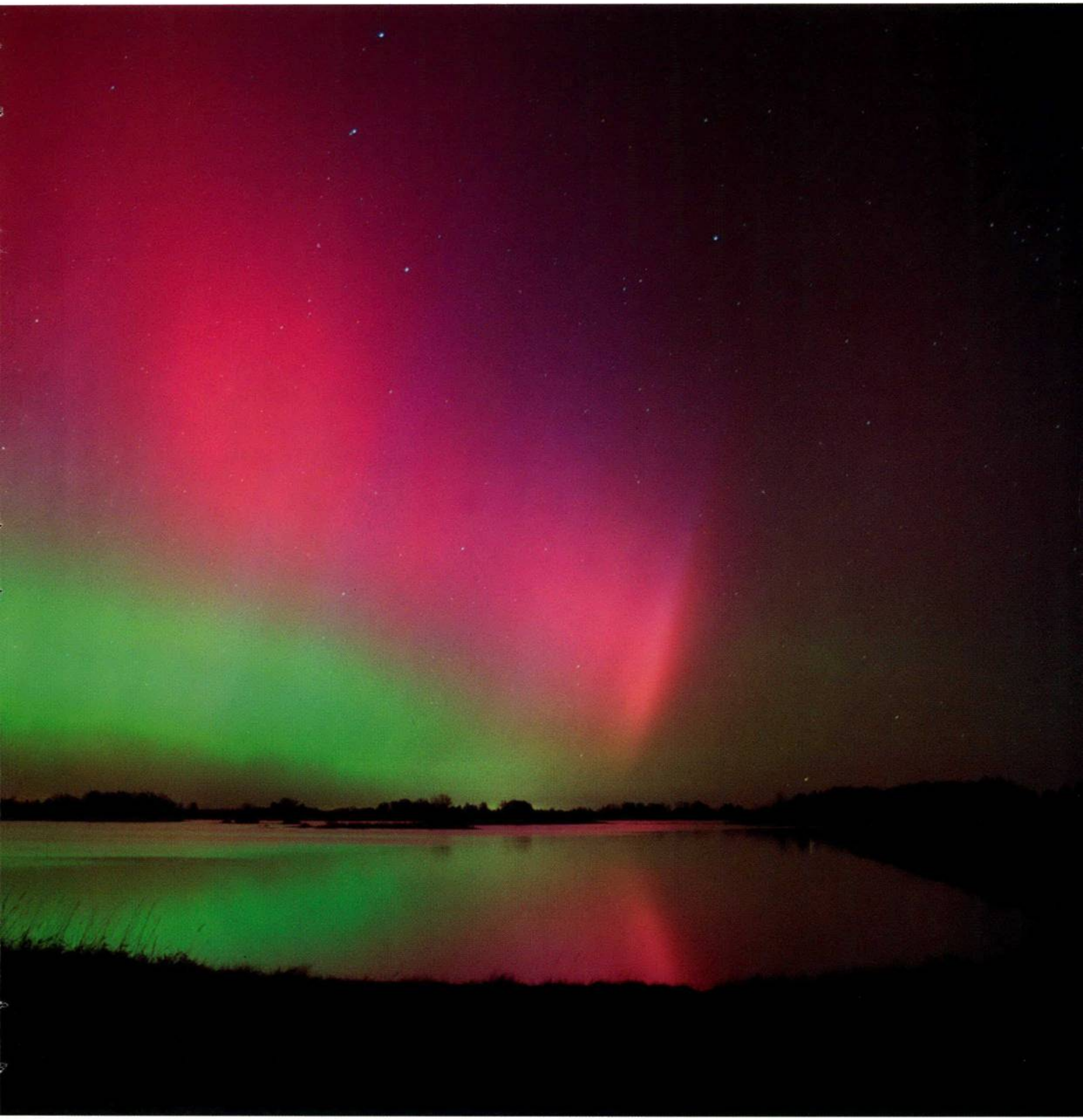


Orion

JOHN CHUMACK

(124mm lens, Kodak 400 film, 20-minute exposure)





Wisconsin Aurora

CHRIS VEN HAUS

(24mm lens at f/2.8, Fuji Superia Xtra 800 film, taken October 28, 2001)

Above: Moon, Venus, and Jupiter

RANDALL WEHLER

(135mm lens at f/2.8, Kodak Elite 200 film, 5-second exposure taken April 22, 1998)

Right: Jupiter and its moons Io, Europa, Ganymede, and Callisto

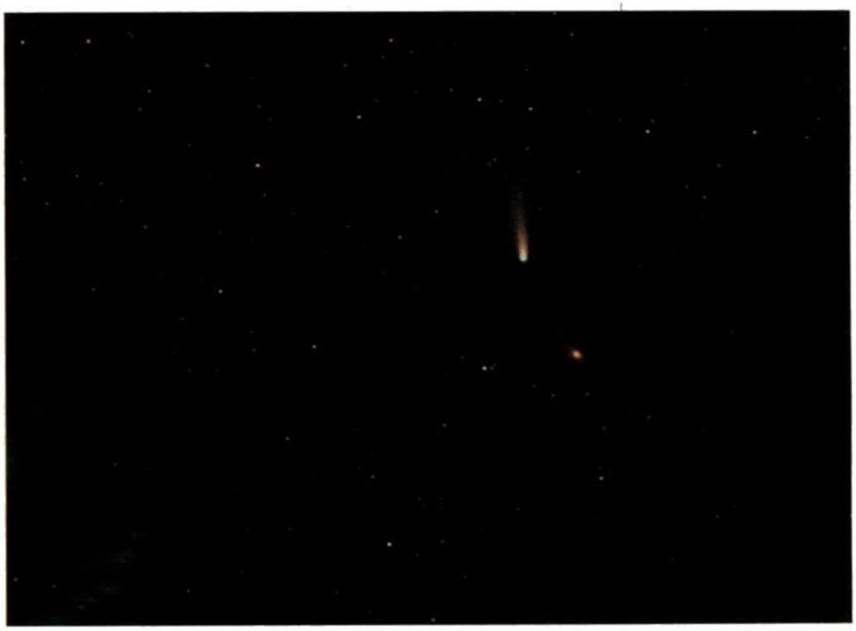
JOHN CHUMACK

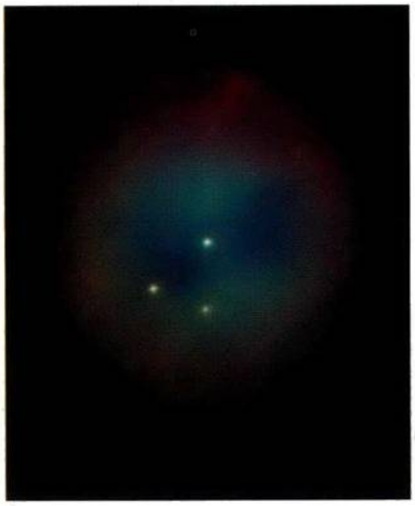
(10-inch SCT at f/6.3, ST-9E CCD camera, composite of two exposures)

Below: Comet Ikeya-Zhang and M31

TIM CRAWFORD

(12-inch SCT, 135mm lens, Kodak 400 Royal Gold film, 3-minute exposure taken April 4, 2002))

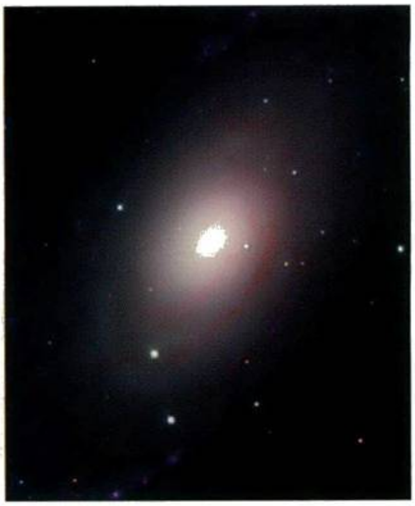




Owl Nebula

JOE PETRICK

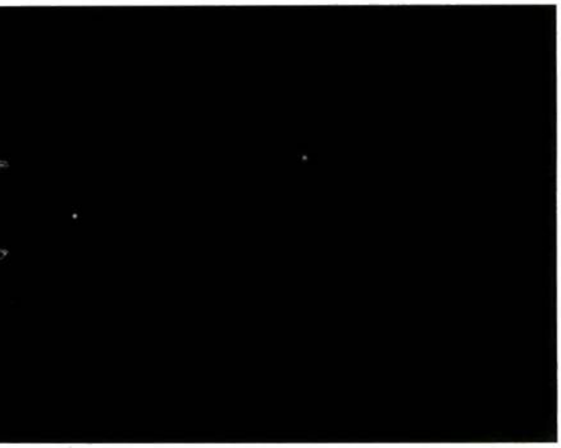
(12-inch SCT, Pictor 416 XTE CCD camera, composite exposure)



M81

CHRIS SCHUR

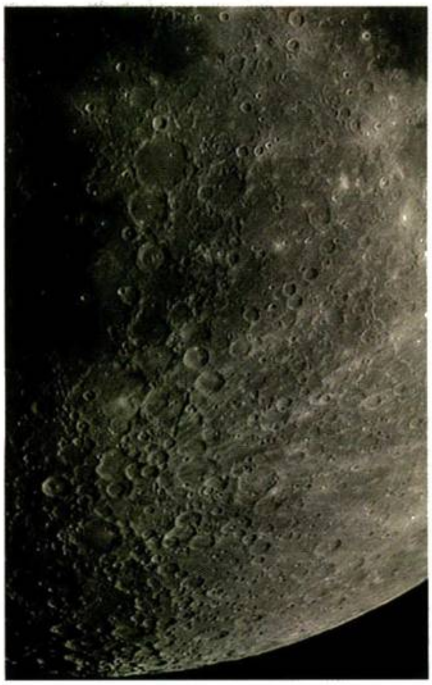
(12.5-inch reflector at f/5, SBIG ST-7E CCD camera, composite exposure)



Saturn

JOE PETRICK

(12-inch SCT at f/10, Pictor 416 XTE CCD camera, composite exposure taken January 28, 2002)



Moon

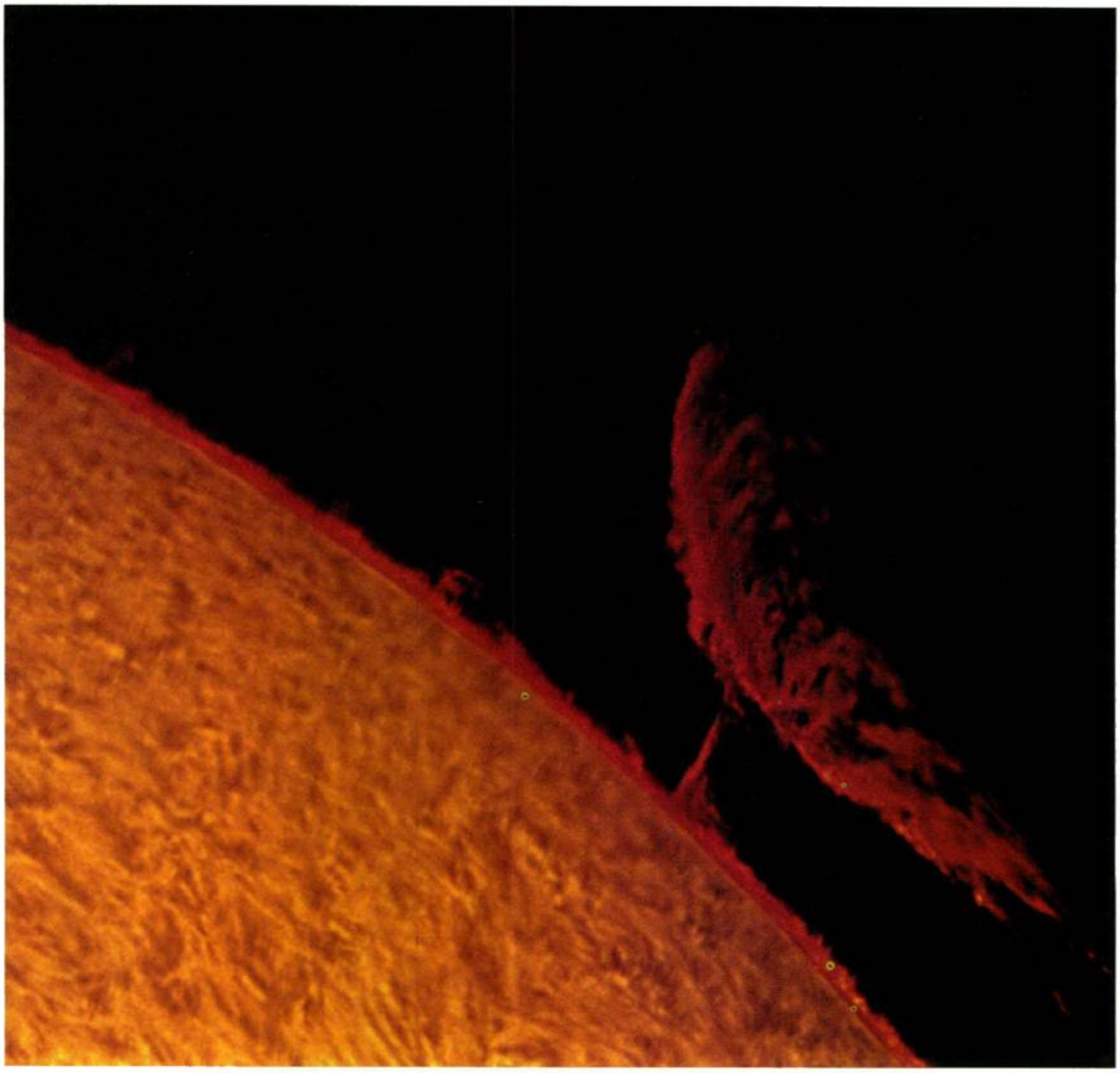
MATHEW RUSSELL

(11-inch SCT at f/10, SBIG ST-10E CCD camera, 0.3-second exposure taken February 22, 2002)

Left: Leonid Meteor Shower

JAMES HAMMOND

(50mm lens at f/2.8, Fuji Superia 400 film, 10-minute exposure taken November 17, 2001)



Above: Solar Flare

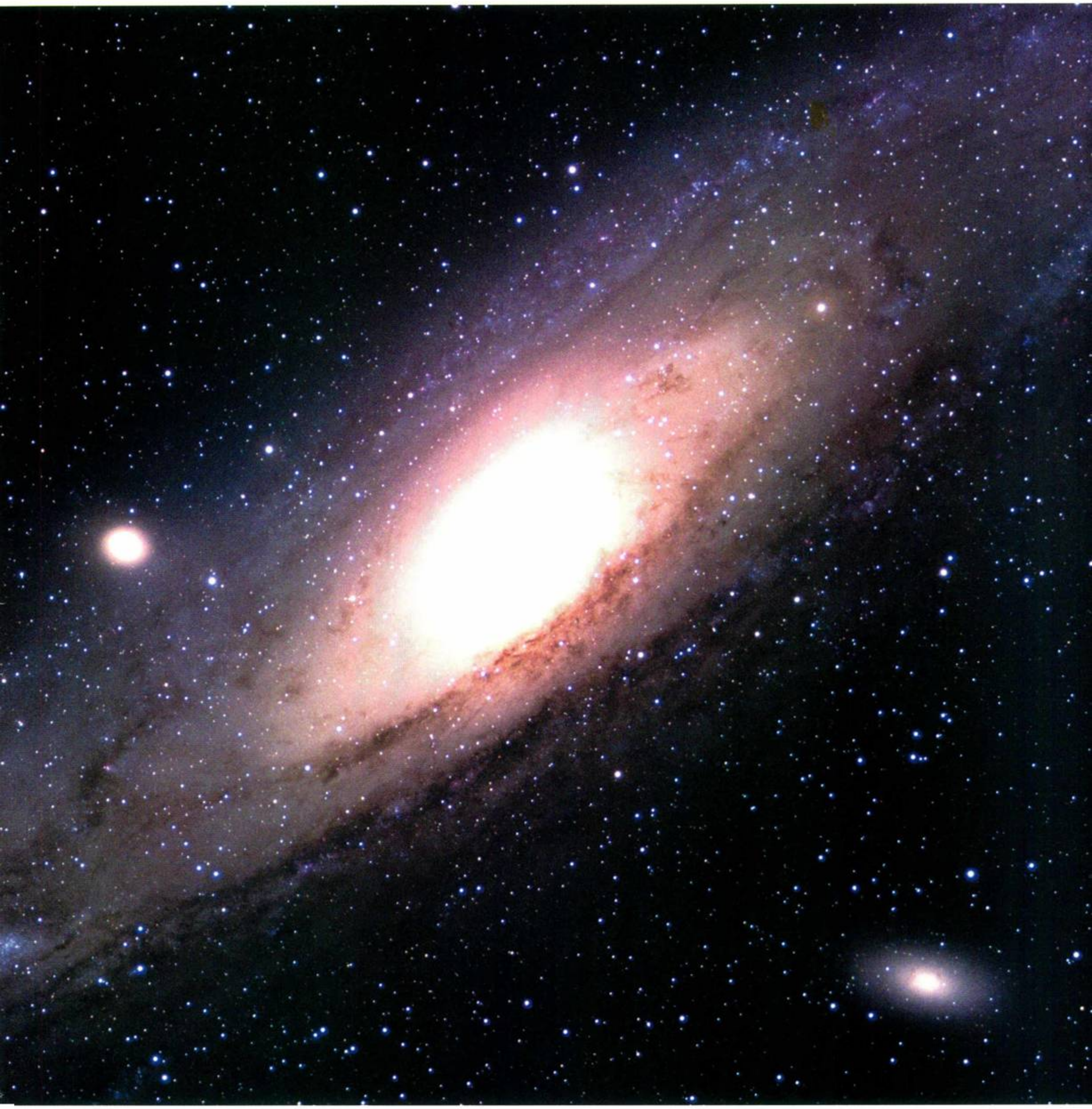
JACK NEWTON

(5-inch apochromatic refractor at f/32, Meade 1616XTE CCD camera)

Comet Ikeya-Zhang

MATHEW RUSSELL

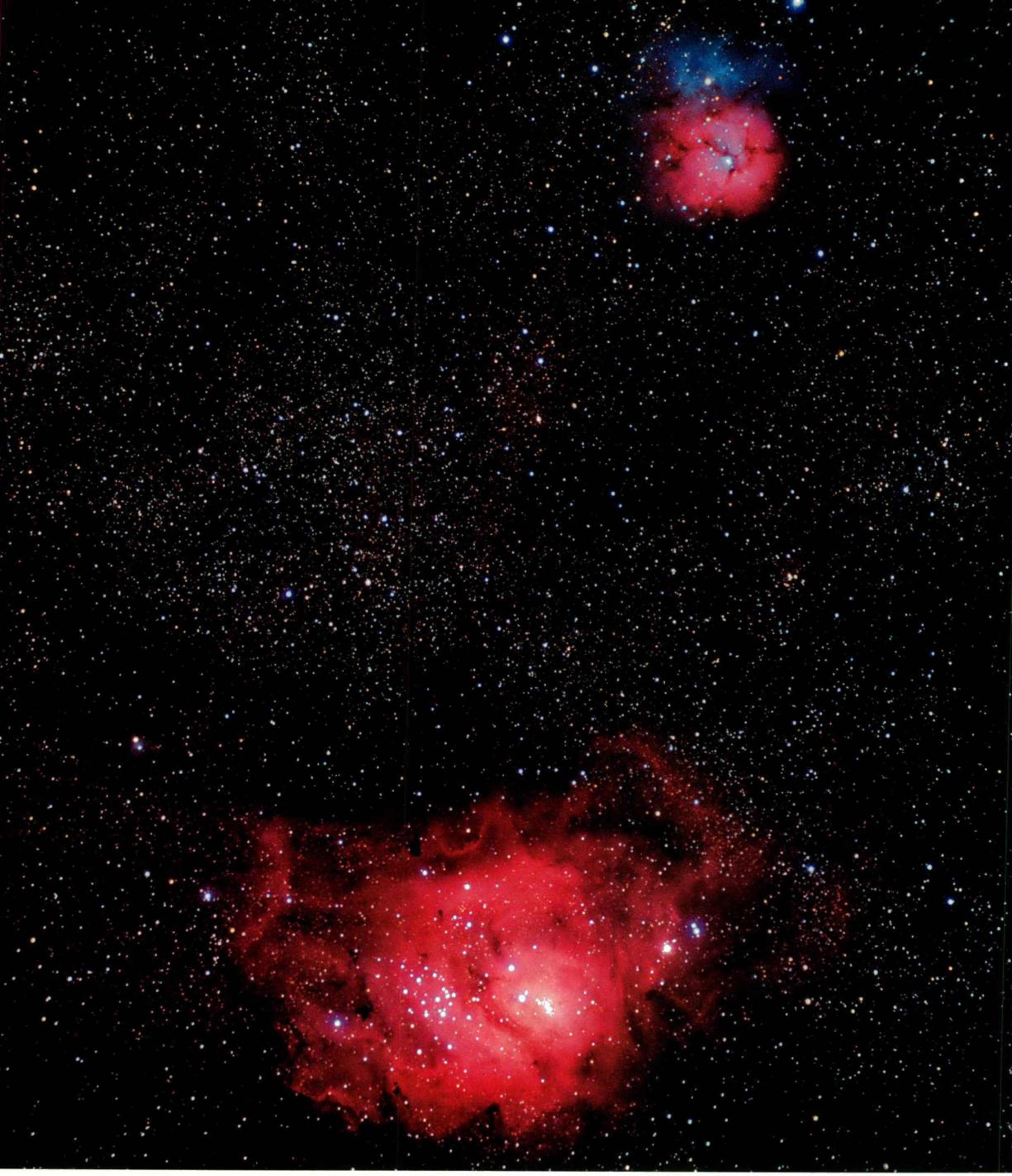
(4-inch refractor at f/5, SBIG ST-10E CCD camera, composite exposure taken March 16, 2002)



M31

CHUCK VAUGHN

(130mm refractor at f/8, Kodak Tech Pan film, composite exposure)



M8 and M20

JASON WARE

(6-inch refractor, composite of two 30-minute exposures on Kodak PPF 400 film and one 90-minute exposure on Kodak Tech Pan film)

SkyQuest™
One Size Fits You!

Better Dobsonian scopes that deliver the goods, whether you're a novice or a night-sky aficionado.

Starting at $199

FREE Color CATALOG!
Call toll-free
(800) 447-1001
or request it online.

ORION
TELESCOPES & BINOCULARS
Everything for the Amateur Astronomer — Delivered Direct
telescope.com

TELESCOPES

MEADE®

FOR EVERY OBSERVING REQUIREMENT

Whatever your budget or observing level, there's a Meade telescope that's right for you. Complete **Digital Series** telescopes from $249 to $499; **ETX Series** from $349 to $895; **LXD55 Series** from $579 to $995; fully computerized **LX90 and LX200GPS** telescopes from $1695 to $14,950.

MEADE LX200GPS
MEADE LX200GPS
MEADE LX200GPS

Background: The Swan Nebula (M17) in Sagittarius. Astrophoto by Jason Ware with the Meade 16" LX200 Schmidt-Cassegrain telescope.

Meade LX200GPS Series
right-to-left: 8", 10" and 12" LX200GPS Schmidt-Cassegrains

Meade astronomical telescopes are offered at over 3000 store locations throughout the United States and Canada.

New 2002 - 2003 Meade General Catalog!

Call, write or fax for your free copy.

ADVANCED PRODUCTS DIVISION
Meade Instruments Corporation
The largest-selling telescopes in the world. ■ *A NASDAQ® company.*
6001 Oak Canyon, Irvine, California 92618 ■ (949) 451-1450
1-800-62-MEADE ■ FAX: (949) 451-1460 ■ *www.meade.com*

© 2002